# ENGINEERING

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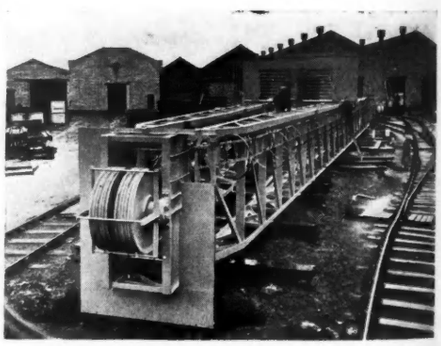

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# Contents

**264 British Association Papers**

Future Growth of World Communications
*By Sir Gordon Radley, K.C.B.*

Stator-Fed Variable Speed AC Motors
*By J. C. H. Bone*

Foundation Design for Modern Buildings
*By T. Whitaker*

**258 Design**

Components to Match Today's Aircraft

Arduous Duties for Rubber Tyres, Intercoolers Raise Engine Output on New Locomotives

**273 New Plant and Equipment**

Photo-electric Relay, Centrifuge, Welding Flux Separator, Radioactive Scanner, Tipped Twist Drill, Magnetic Tape Transport

*European Machine Tool Exhibition:* Hob Sharpener, High-Speed Hydraulic Press, Milling and Boring Machine, Tool-Room Boring Machine, Surface Grinder, Cutter-Grinding Machine

**275 Construction**

Prestressed Quay Constructed " In the Wet "

**278 Metals and Materials**

Off-the-Coil Prepainted Metal Strip

Structural Steel Shot-Blasted and Primed, Epoxy Powder for Hot Dip Coating, One-Coat Acrylic Finish, Strengthened Pvc for Scrubbing Tower, Baked-on Coating of Molybdenum Disulphide, Detector of Carbon Monoxide

**280 Production**

Ergonomics, Its Purpose and Potential

Fabrication Problems with Tantalum, De-stressing Continuous Railway Lines, Stress Relief of a Reactor Vessel, Shipyard Handling by Tractor

**289 Research**

*Research Report:*

Two Facets of Economic Central Heating

Large Rocket Engine Demonstrated, Research into Mechanized Plastering, Flash Welding of Light Alloys, Ruby Maser as Light Amplifier

**257 Impact**

**263 Human Element**

**277 Companies**

**285 Marketing**

**262 Automobile Review**

Ferguson Station Wagon Designed for Safe Driving, French Governor for Diesel Fuel Pump

**286 Product Profile**

Martin-Baker Mark IV Ejection Seat

**292 At Home**

Model Charm

**261 Plain Words**

*By Capricorn*

**261 Letters to the Editor**

Need for a Water Grid
*J. F. Pownall*

**261 Events in Advance**

**282 Publications**

On the Shelf
*By Frank H. Smith*

*Books Reviewed:*

Seven into Space: The Story of the Mercury Astronauts

Fundamentals of Signal Theory
Statistical Theory of Communication

The Electron Microscope: the Present State of the Art

The Spring

Trade Publications and New Books

**Cover Picture**
Final process of fettling two 20 ton ingot moulds. The moulds will then be ready for dispatch to the steelworks. (*Nurnberg photograph for* ENGINEERING)

Subscription Rates: Editorial page 292

Index to Advertisers: Overleaf

Engineering Appointments Section: Faces Editorial page 276

# Advertisers in 'Engineering' this week


| | PAGE |
|---|---|
| Aabacas Eng'g. Co., Ltd. | 14 |
| Armstrong Stevens & Son, Ltd. | 52 |
| Ashmore, Benson, Pease & Co., Ltd. *Wrapper* | III |
| Associated Electrical Industries, Ltd. Electronic Apparatus Division. *Wrapper* | VII |
| Motor & Control Gear Division. *Wrapper* | VII |
| Switchgear Division. *Wrapper* | VIII |
| Turbine - Generator Division. | 33 |
| Auld, David, & Sons, Ltd. | 12 |
| Austin, E., & Sons (London) Ltd. | 52 |
| B.E.N. Patents, Ltd. | 66 |
| Bailey, Sir W. H., & Co., Ltd. | 31 |
| Balfour, Arthur, & Co., Ltd. *Wrapper* | IV |
| Beardmore, W., & Co., Ltd. | 45 |
| Bird, W. H., & Sons, Ltd. | 66 |
| Blackstone & Co., Ltd. | 18 |
| Booth, John, & Sons Bolton) Ltd. | 31 |
| Booth, Joseph, & Bros. | 50 |
| Brayshaw Furnaces, Ltd. | 6 |
| British Steam Specialties, Ltd. | 55 |
| Broom & Wade, Ltd. *Wrapper* | VI |
| Brown, E. G., & Co., Ltd. | 14 |
| Budenberg Gauge Co., Ltd. | 65 |
| C. & M. Eng'g. Co., Ltd. | 52 |
| Carobronze, Ltd. 14 & | 55 |
| Chatwin, T., & Co. | 35 |
| Chesterfield Tube Co., Ltd. | 69 |
| Clark, G., & Sons (Hull) Ltd. | 66 |
| Clarke, Chapman & Co., Ltd. | 23 |
| Clyde Crane & Booth, Ltd. | 50 |
| Clyde Crane & Eng'g Co. | 50 |
| Clyde Rubber Works Co., Ltd. | 36 |
| Consolidated Pneumatic Tool Co., Ltd. | 72 |
| Constructors John Brown, Ltd. | 30 |
| Cox & Danks, Ltd. *Wrapper* | V |
| Crane, Ltd. | 36 |
| Crofts (Engineers) Ltd. | 60 |
| Crossley Brothers, Ltd. | 54 |
| Davidson & Co., Ltd. | 24 |
| Day, James (Machinery) Ltd. | 49 |
| Distington Eng'g Co., Ltd. | 19 |
| Dowty Seals, Ltd. | 42 |
| Drysdale & Co., Ltd. | 10 |
| Dyson, R. A., & Co., Ltd. | 52 |
| Engelhard Industries, Ltd. | 22 |
| "Engineering" Quickbinde | 9 |
| English Electric Co., Ltd. Industrial Motors Division | 58 |
| Escher Wyss, Ltd. | 20 |
| Everett Edgcumbe & Co., Ltd. | 61 |
| Fairfield Shipbuilding & Eng'g. Co., Ltd. | 48 |
| Firth Brown Tools, Ltd. | 43 |
| Fleming & Ferguson, Ltd. | 9 |
| Follsain-Wycliffe Foundries, Ltd. | 35 |
| Foster Wheeler, Ltd. | 64 |
| Frank, Charles, Ltd. | 14 |
| Fraser & Fraser, Ltd. | 46 |
| Glenfield & Kennedy, Ltd. | 57 |
| Gre-Solvent Company | 11 |
| Greening, N., & Sons, Ltd. | 55 |
| Greenwood & Batley, Ltd. | 29 |
| Greenwood's Standard Gear Cutting Co., Ltd. | 28 |
| Hack Saws, Ltd. *Wrapper* | V |
| Harvey, G. A., & Co. (London) Ltd. | 17 |
| Hitachi, Ltd. | 71 |
| Hopkinsons, Ltd. | 68 |
| Horne Eng'g. Co., Ltd. | 55 |
| Hot Dip Galvanizers Association | 8 |
| Jackman, J. W., & Co., Ltd. | 11 |
| Klinger, R., Ltd. 62 & | 63 |
| Kompass Register, Ltd. | 5 |
| Lees, H., & Co., Ltd. | 28 |
| Massey, B. & S., Ltd. | 59 |
| Midland Silicones, Ltd. | 67 |
| Mono Pumps, Ltd. | 7 |
| Morgan Refractories, Ltd. | 39 |
| Morris, Herbert, Ltd. | 10 |
| Motor Gear & Eng'g. Co., Ltd. | 7 |
| Neill, J., & Co. (Sheffield) Ltd. | 9 |
| North British Locomotive Co., Ltd. | 53 |
| Oddy Eng'g. Ltd. | 26 |
| Osborn, Samuel, & Co., Ltd. | 21 |
| Palnut Co., Ltd. | 28 |
| Pickering Group of Companies *Wrapper* | II |
| Pool, J. & F., Ltd. | 46 |
| Pratt Precision Hydraulics, Ltd. | 18 |
| Priest Furnaces, Ltd. | 31 |
| Pye-Ling, Ltd. | 13 |
| Rawlplug Co., Ltd. | 27 |
| Raybestos-Belaco, Ltd. | 35 |
| Reyrolle, A., & Co., Ltd. | 51 |
| Rice & Co. (Leeds), Ltd. | 2 |
| Riley, A. J., & Son, Ltd. | 70 |
| Robertson, W. H. A., & Co., Ltd. | 38 |
| Robinson, L., & Co. (Gillingham) Ltd. | 26 |
| Robinson, Thos., & Son, Ltd. | 59 |
| Savery Thomas, Pumps, Ltd. | 2 |
| Seagers, Ltd. | 28 |
| Simplifix Couplings, Ltd. | 11 |
| Skefko Ball Bearing Co., Ltd. | 32 |
| Smith & Grace, Ltd. | 36 |
| Smith, J. (Keighley) Ltd. | 34 |
| Smiths Industrial Instruments, Ltd. | 25 |
| Staedtler, J. S., Ltd. | 26 |
| Steel Company of Wales, Ltd. | 16 |
| Steel Construction Co., Ltd. | 52 |
| Steels Engineering Installions Ltd. | 56 |
| Steels Engineering Products, Ltd. | 47 |
| Stewarts and Lloyds Plastics, Ltd. | 44 |
| Stothert & Pitt, Ltd. | 37 |
| Sulzer Bros. (London) Ltd. | 12 |
| Super Oil Seals & Gaskets, Ltd. | 46 |
| Tecalemit, Ltd. | 40 |
| Teddington Aircraft Controls, Ltd. | 15 |
| United Filters & Eng'g. Ltd. | 31 |
| United Steel Companies, Ltd. | 19 |
| Vosper, Ltd. | |
| Ward, Thos. W., Ltd. | |
| Wigglesworth, Frank, & Co., Ltd. | |
| Wilkinson Rubber Linatex, Ltd. | |
| Worcester Valve Co., Ltd. | |
| Youngs (Lifting Appliances) Ltd. | |

**'Engineering' Appointments Section** inside Editorial Section

| | |
|---|---|
| British Hydrocarbon Chemicals, Ltd. | 1 |
| English Electric Co. Ltd. | 2 |
| Ferodo, Ltd. | 3 |
| Personnel Administration Ltd. | |
| Tube Investments, Ltd. | |
| Vickers-Armstrongs (Engineers), Ltd. | |

**Classified: Trade & Technical**

| | |
|---|---|
| College of Aeronautics | 3 |
| Edwards, F. J., Ltd. | 3 |
| Government Surplus Stores | 3 |
| Haseltine Lake & Co. | 3 |
| India Store Department | 3&4 |
| Mahoney, Daniel, Taylor & Co. | 3 |
| New South Wales, Govt. of, | |
| Nigeria, Electricity Corpn. of, | |
| Norris Bros. Ltd. | |
| Research Engineers, Ltd. | |
| Soag Machine Tools, Ltd. | |
| Ward, Thos. W., Ltd. | |


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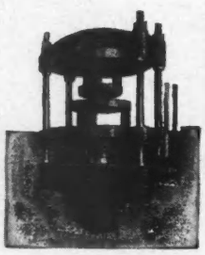

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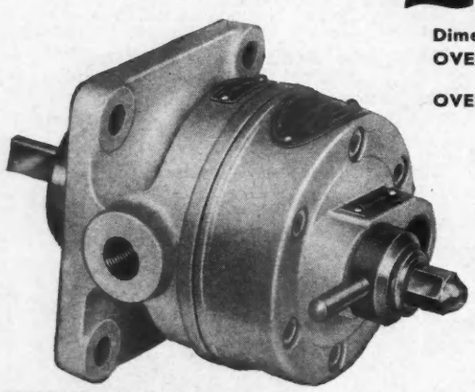

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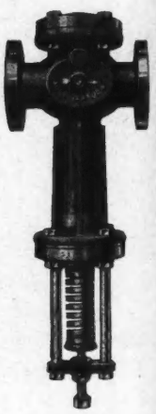

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# ENGINEERING Impact

## of Engineering Plant Available on Lease

PAY-AS-YOU-USE techniques covering the leasing of vehicles, machinery and equipment of all kinds are to be introduced into Britain. They have already been operated with marked success in the United States during the last few years.

To this end, a new company has been formed by Hambros Bank, Phoenix Assurance Company, and Cable and Wireless (Holding) Limited, in association with the Lease Plan International Corporation, a New York concern which specializes in this type of business in the United States.

Lease Plan International have three major divisions: one is concerned solely with financial leasing, and another with truck leases, which are restricted to motor vehicles and cover maintenance and insurance, as well as the simple financial leasing aspect. The last is the contract lease division, which comprises all the features of the other two and provides manpower as well. The company's interests are in providing money for productive goods and not in consumer end-product financing.

Initially, the British firm will concentrate on finance leasing, but may well extend their activities later. American experience has shown that the most usual items for leasing are machine tools, electronic equipment, chemical process equipment, cars, lorries and office furniture, but the system is designed to range from electric drills to fully-equipped engineering factories, and including ships and aircraft.

## Customers Choosing the Plant They Like

TO BE known as Equipment Leasing Company Limited (ELCO), the new British leasing company will have an authorized capital of £500,000 in one-pound shares and will commence their operations from offices in Leadenhall Street, London, on 1 October next. At least 50 per cent of the shareholding will be in British hands and Lease Plan International will own about 25 per cent of the capital.

Equipment Leasing will purchase the equipment specified by their customers and then lease it to them, charging a rent based upon the cost of the equipment and the period of the lease. The scheme differs from hire purchase in that the equipment will always remain the property of Equipment Leasing. Ownership will not pass to customers. As far as possible equipment will be purchased in Britain, unless a customer desires otherwise. The system is stated to be cheaper than hire purchase and its advantage is that it leaves firms' working capital free for more profitable employment in other directions.

Mr. H. L. Meckler, who is president of Lease Plan International and is to be the chairman of Equipment Leasing, has summarized the system as being "a financial middleman: a sort of buffer between the manufacturer and the user of a piece of equipment."

In the United States, this type of business has expanded from a turnover of $10 million in 1952 to between $400 and $500 million this year, and is expected to reach $1,000 million by 1965. Mr. Meckler anticipates spending several million pounds during the first year of the new company's existence, principally in financing projects needing £5,000 and above.

The revenue of Lease Plan International has risen to $26 million this year and the firm claims to be one of the three largest purchasers in the world of rolling stock.

## Prices Paid by Industry for Coal

THE price of coal is a matter of much concern to both the user and the producer. A large concern, such as a cement manufacturer, may be using 3,000,000 tons or more a year; even a small reduction in the price per ton, or the quantity burnt per ton of product, can be reflected in a substantial annual saving.

It would also be possible in this particular industry to effect savings if the quality of the coal were consistent. Such consistency would enable the ash to be used in manufacture, but variation in the ash content of fuel supplied, which the National Coal Board is apparently unable or unwilling to standardize, leads to waste.

Industrialists in their search for cheaper fuel have explored the possibilities of importing lower-priced coal, burning coal in a different form, or changing over to oil or gas. An application to import fuel from Poland is now forthcoming from the Tunnel Portland Cement Company Limited. This was announced by Mr. N. M. Jensen, the company's chairman and managing director, in his review circulated with the annual report. He pointed out that with the rate of taxation now ruling, fuel oil is costing his company 60*s* to 71*s* per ton more than the price paid by some continental competitors.

It is apparently only two or three years since the company decided to switch over to oil fuel and assurances were given that reversion to coal would present no difficulty. A recent approach to the Coal Board has shown that the quality required by the company is not available and that prices have risen substantially. At the same time, the review states, British coal is being sold to continental competitors at prices approximately two-thirds of those charged in Britain. While this policy benefits the Board's exports it adds to the problems of other exporters.

Much has been done by British industry to reduce fuel costs. As an example, in the last 35 years, the quantity of coke required to produce a ton of pig iron has been lowered from some 25½ cwt to about 16 cwt. The Coal Board is fully alive to the necessity of reducing industry's fuel bill, as costly coal leads customers to explore—and in some instances to use—competitive forms of heating. It is better that the Board should supply a customer with smaller quantities than none at all—which may well be the alternative. As an illustration of this awareness, experiments sponsored by the Board are being carried out at the Stanton Ironworks, where a furnace is being converted to burn milled coal.

The scheme, at Stanton, financed by the Coal Board, provides for the automatic injection of coal into the furnace through lances in the furnace tuyeres. This process, Lord Robens has pointed out, in addition to saving money (as the coal will be cheaper than the coke replaced), will increase furnace throughput, for space in the furnace which was formerly occupied by the charge of coke can now be filled with ore.

## of a High Road into the Market

THE French have been sold on a permanent crossing of the Channel ever since the first proposals were made 100 or so years ago. Now comes the news that the French Government are again going to take up the issue with their British counterparts. The official statement from Paris speaks of an *ouvrage fixé*, but pointedly avoids any indication of whether a tunnel, a tube or a bridge is preferred.

The arguments for and against each type of crossing are now fairly well known. Cheapest would be a tunnel, but it would have to be limited to electric rail stock and (with available prospecting methods) there would be the risk of an insoluble difficulty until the last foot was driven. The tube would be more expensive, but there is good authority for believing that it would be practicable for road as well as rail—it would involve a much shorter route and therefore ventilation would be relatively simpler—and the geological risk would be negligible. Top of the bill is a bridge; it has all the advantages of the tube only more so—ventilation would be a negative problem—and all sorts of mains can be slung below the deck.

Against the bridge, apart from the cost and the possible danger to concentrated shipping routes, has been maintenance. This concern, however, has always been based on the assumption that the superstructure would have to be of steel. The most recent proposal for a steel bridge envisages 115 ft wide deck for road and rail tracks, 230 ft above sea level to give clearance for the largest ships, and spans of 660 ft. Five years ago—even less—nobody could have seriously considered such a structure in prestressed concrete. Today cantilever spans of nearly 500 ft and a 1,000 ft arch are being built in prestressed concrete. No one knows what the life of a bridge in an unrelieved sea atmosphere would be but it is certain that it would be cheaper to give a long-life potential to a concrete than a steel bridge.

And if the French want the bridge, it would be a nice bait for them to say to Britain that road traffic, as well as rail, could travel on the left.

## Old Cars, Lamp-posts and Road Accidents

THE relative accident rates of cars of differing ages is still a matter of some controversy. After six months operation of the ten-plus car test scheme, accident rates are still climbing.

Figures released by the Road Research Laboratory in their latest annual report show that, in 1957, cars up to two years old were involved in 13·1 personal injury accidents per 1,000 vehicles licensed, cars from three to ten years old varied almost linearly between 7·9 and 9·7 per cent per 1,000 vehicles, and cars of more than ten years age had the lowest figure of all—5·6 per cent.

Although it is true that these figures do not take account of the probable lower mileage rates of older cars, a factor which could completely alter the relative accident percentages, it would appear that the age of a vehicle is not a *primary* factor in road safety: driver judgement is evidently far more significant.

Further analysis of the accident rate in relation to vehicle age indicates that older cars may have a higher rate during night driving, because of a higher incidence of lighting faults.

In addition to increasing their research on factors affecting accident rates, the Road Research Laboratory are continuing their investigations into the causes of accident injury. Much can be done to reduce the severity of accident injury, particularly through the use of safety belts and by certain changes in the design of motor vehicles which are gradually being adopted by car manufacturers.

However, it is not only in the design of the vehicle itself that a reduction in accident severity can be affected. The report points out that, in 1956, about 800 occupants and drivers were injured or killed in collisions with street lighting columns in the London Metropolitan area alone. By experimenting with various types of structure, it has been found that lighting columns made of thin sheet-steel, with their low modulus of rupture, could reduce the seriousness of collisions very considerably.

## Greater Demands for Ready-mixed Concrete

MUCH greater use is being made of ready-mixed concrete and this tendency seems likely to continue. The principal advantage of the new practice is that it obviates the need for plant and storage on restricted sites. In 1951, there were only 12 plants preparing ready-mixed concrete. Today there are more than 300.

The Cement and Concrete Association state that they will continue to give their support to the efforts of the producers of ready-mixed concrete to ensure this material retains its present high standard of quality.

Taking the country as a whole, the association have found that there has been a steady improvement in the utilization of concrete, both technically and architecturally, but consider that there are fields in which quality and design are still not as good as they could be.

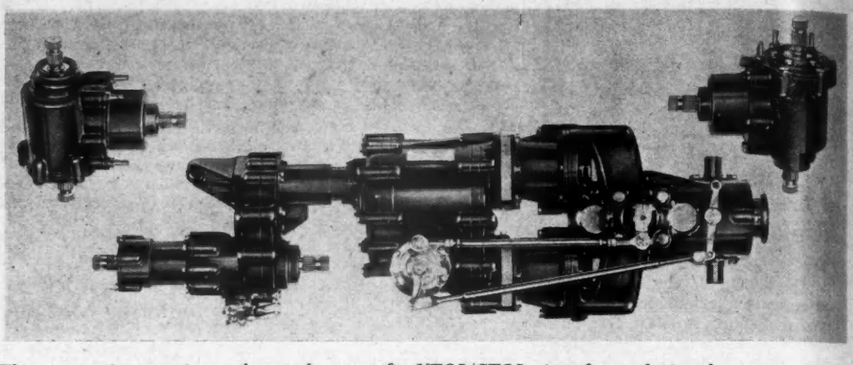
There is great scope for the increased use of precast concrete products of all kinds, but here again, much work is required, particularly in regard to design—functional as well as aesthetic—before they can be used to full advantage.

Interesting new developments are in the offing in the use of concrete and the future in the whole field seems bright. Indeed the Hon. L. O. Russell, director-general of the association, feels that we can look forward to further progress during the next few years.

# Components to Match Today's Aircraft

**The aircraft industry, probably more than any other, needs behind it a component industry each section of which must be capable of designing and producing exactly what is required.**

DEMAND for stand space at this year's SBAC Show to be held at the Royal Aircraft Establishment, Farnborough, has been greater than ever before. As usual, components figure very largely in the Show and this article gives details of a few of them. Next week, it is hoped to give highlights of some of the aircraft to be seen at the Show and in the Flying Display.



*This pneumatic actuation and control system for VTOL/STOL aircraft, employing the rotating nozzle principle, only requires bleed air from the engine it controls.*

## Control System for VTOL/STOL Aircraft

A pneumatic actuation and control system for VTOL and STOL aircraft employing the rotating nozzle principle is now available. Such an engine could be the Bristol Siddeley Pegasus as used in the Hawker P 1127.

Made by Plessey, this system supplies the power to rotate the final jet nozzles to any desired position with considerable accuracy. Some particular features of the system are the high response rate, ability to withstand wide temperature changes and freedom from aerodynamic creep. The system is entirely self-contained and only requires bleed air from the engine which it controls.

Among the fuel systems Plessey have developed is one designed to meet the requirements of jet lift engines. It is compact and light, thus enabling the engines to have the high thrust/weight ratios necessary. The pilot's control lever enables the thrust of the engines to be modulated and the selected thrust is maintained irrespective of altitude and ambient conditions. In an emergency the system allows for an engine to be uprated.

*The Plessey Company Limited, Ilford, Essex.*

## Increased Reliability Transitor Circuit in Radar Display System

A system availability of over 99·8 per cent is said to have been achieved with the prototype of a new and complex radar display system under trials in Decca Radar's laboratories. This performance has been sustained over the whole period of the trials which already exceed 10,000 hours.

*Production version of the Decca transistorized display equipment. Environmental stabilization is provided by duplicate liquid cooling units and an associated heat exchanger in the lower right hand cabinet, the remaining cabinets containing the transistor circuit boards.*

Such an advance in reliability has been made possible by a new technique developed by Decca based on Environmental Stabilization, whereby all circuits and transistors are maintained at constant internal temperatures to within ¼° C and at controlled humidity. Liquid cooling provided by an internal refrigeration unit and heat exchanger, combined with a mechanical design which gives good thermal insulation is the basis of the advance.

This arrangement has successfully handled ambient temperature variations between 0° and 45° C, with relative humidity ranging from 10 to 90 per cent. During the 10,000 hour trials, mains voltage varied by ± 15 per cent, but stability was said to be such that display error was consistently less than 0·2 per cent overall and less than 0·8 per cent for short term measurements.

The new system makes possible the reliable employment of transistors in electronic equipment where very high standards of performance and circuit stability are required. In the engineering of typical data handling and display systems for civil and military operations rooms, and in naval vessels, it enables a reduction in power consumption by a factor of approximately eight.

The need for minimum servicing attention which can now be achieved even where great complexity and elaboration must be introduced to meet exacting operational requirements is also of importance.

Following on the successful operation of their prototype equipment, Decca have developed production equipment and are now completing units for early delivery in a military project.

*Decca Radar Limited, Albert Embankment, London SE1.*

## Mirror Deck Landing Projector Sight

Details have been released by the Admiralty of a deck landing projector sight developed by the Hirst Research Centre of GEC in conjunction with Admiralty and manufactured by the company.

The optical system consists of a vertical bank of twelve precision projectors—of the slide projector type—each giving a beam of very small vertical spread. Horizontally the beams are spread over 40° so that the pilot can pick up the indication as he turns on to the final approach. In the vertical sense, the beams are set at intervals of 8′ of arc so that the total vertical spread is about 1½°.

The beams are orange in colour and the effect of the small angular separation is that a pilot on the correct glide path will only see the two centre ones as orange lights. To assist him in finding the centre, a row of six green lights (three on each side of the vertical bank) is arranged horizontally on the centre line and forms a datum. Thus the vertical position of the orange lights with respect to the green datum lights will tell him immediately if he is above or below the glide path and how much correction to apply.

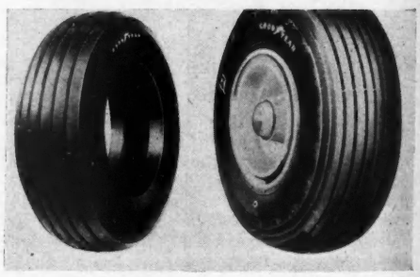
There are in addition two " wave off " lights used to indicate that a safe landing cannot be made and the aircraft must fly on and circle for another approach.

*The General Electric Company Limited, Magnet House, Kingsway, London WC2.*

## Cool Tyres for Hot Aircraft

The Goodyear Thermal tyre has been specified for the Bristol 188 all-steel research aircraft. This tyre substantially lowers the overall cost of the aircraft by eliminating the need for refrigeration equipment normally required to protect conventional tyres from external heat developed at very high speeds.

The superior heat resistance of the tyre is attributed to Goodyear's new formulations for compounding and perfecting the materials used in the carcass and tread.



*(Left) The Goodyear Thermal tyre will be fitted on the Bristol 188 research aircraft. (Right) The "Blue Dot" tyre eliminates valves and cores and simplifies wheel design.*

Another Goodyear tyre, the " Blue Dot," works on the sidewall inflation principle which eliminates conventional valves and cores and simplifies wheel design.

*The Goodyear Tyre and Rubber Company (Great Britain) Limited, Wolverhampton.*

## Precision Altimeter with Good Readability

Specified for the VC10 is the Kelvin Hughes

*This precision altimeter combines great accuracy with maximum readability.*

servo precision altimeter. The presentation adopted by BOAC features a single Perspex pointer with a white-painted tip which makes one complete revolution per 1,000 ft. Large digital counters outlined boldly in a white rectangle show altitude to the nearest 50 ft. Required cruise altitude can be selected by means of a control on the front of the instrument case which operates a similar counter positioned above the dial itself. Power failure warning is by means of an illuminated black and yellow-striped indicator in the dial plate.

This precision altimeter is a servo-operated presentation unit receiving signals from a remote-mounted computer unit and combines accuracy with maximum readability. This high inherent accuracy stems from improved pressure measurement made possible by the force balance unit employed in the computer.

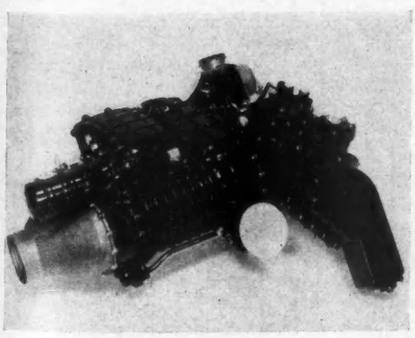
*Smiths Aviation Division, Kelvin House, Wembley Park Drive, Wembley, Middlesex.*

## Gearbox Compressor for Air-Conditioning Systems

Four gearbox compressors of Godfrey/SRM design, type GB80/210 Mk 1, provide the charge air for the pressurizing and air conditioning system in the Vickers VC10. Each is mounted on and driven from an engine installation.

Automatic proportional control of the air mass flow delivered by the compressors is regulated by two electro-pneumatic Godfrey mass flow controllers each monitoring the positions of hydraulically operated slide valves on a pair of compressors.

A gearbox compressor consists of a speed increase gearbox to which is dowelled and bolted a rotary screw type compressor incorporating a slide valve and balance piston assembly. A vertical quill shaft in the gearbox engaging from the engine transmits power through spiral bevel gears to a quill drive in engagement with serrations in the male rotor of the compressor. The effective length of the two helically-lobed intermeshing rotors in the compressor is controlled by the slide valve, which also controls the opening and closing of an integral intake spill duct. An oil system incorporated in the gearbox compressor provides the hydraulic power for operation of the slide valve and lubrication of the gears and bearings.



*Four gearbox compressors of this type provide the charge air for the pressurizing and air conditioning system in the Vickers VC10.*

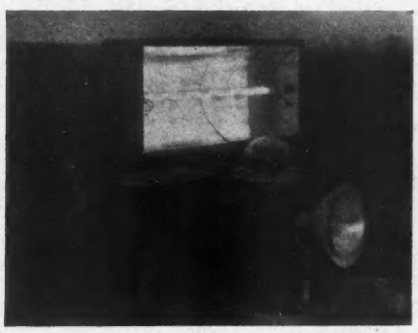
At sea level, with the aircraft engines set at take-off speed, the slide valves are in the minimum delivery position and three quarters of the air flow to the compressors is directed through the intake spill ducts. On climbing, the valves are inched to the maximum delivery position which is reached at an altitude of 40,000 ft with the engine set at cruise speed, when the spill ducts are fully closed.

Manual control of the slide valves is provided in the aircraft electrical circuit by selector switches which over-ride the automatic control and also permit isolation of the compressors. In the event of an hydraulic failure, the balance piston, which is subjected to delivery air pressure, moves the slide valve to the minimum delivery position.

*Sir George Godfrey and Partners Limited, Hampton Road West, Hanworth, Middlesex.*

## Wide-Angle Sodium Lamps for Airfields

The wide angle of visibility obtainable with the linear sodium lamp fitted in a suitable projector, and the reduction in glare which it can provide relative to other lighting, make the new AEI Mazda 200W lamp particularly well suited to airfields where there are no precision approach aids.



*The wide visibility angle obtainable with the 200W Mazda linear sodium lamp in a suitable projector makes it particularly suitable for airfields where there are no precision approach aids.*

Sodium lamps have hitherto only been used for this purpose in daylight because no suitable method has been available for adjusting their brightness to meet varying climatic conditions. The problem involved in providing such adjustment is to maintain the lamp operating temperature constant while the direct electrical input to the arc tube is varied.

With the Mazda lamp this problem has been solved, largely as a result of its more favourable volt/amp characteristic as compared with U shaped tubes. The 200W lamp, built with an integral transparent oven and placed in a simple reflector system, can give outputs ranging from less than 200 candles up to 20,000 candles in a beam extending 8° in the vertical and 60° horizontally.

Field trials of these lamps for aerodrome approach lighting are now in progress on the 10,000 ft runway at Stanstead Aerodrome, Essex.

*AEI Lamp and Lighting Company Limited, Melton Road, Leicester.*

## Aircraft Periscopes for Rear-Mounted Engines

The advent of civil airliners with rear mounted engines such as the Vickers VC10 and the dH Trident has created a new problem—that of making in-flight examination of the engine intakes for signs of fire, ice formation and damage. It could probably be done by a member of the crew walking aft on occasions to view from the rear windows, but as well as being tiresome it would not be particularly good for passenger morale.

For this reason, periscopes have aroused fresh interest. The RAF have used them for a number of years in various bomber aircraft, including V bombers. In these military applications, the instrument is primarily used to look aft from the navigator's position so that any tell-tale contrails made by the aircraft can be seen and the appropriate corrective action taken in good time.

Kelvin Hughes rearward-looking aircraft periscopes have been specified for the VC10 as standard equipment, and other civil aircraft have them for flight trial purposes. The optical system has a magnification of nearly 2 and includes a movable object prism operated through pushrods by a control knob on the body casing. This can be used to control the field of view so as to sweep vertically from the top of the fin and rudder, down to and including the engine air intakes.

When not in use the periscope is retractable in its mounting, the extension above the aircraft skin being approximately 5¼ in when observations are being made. A hatch controlled by a Bowden cable and lever covers the opening to maintain cabin differential pressure and an interlocking mechanism prevents the hatch being opened unless the instrument is inserted in the carrier tube.

*Smiths Aviation Division, Kelvin House, Wembley Park Drive, Wembley, Middlesex.*

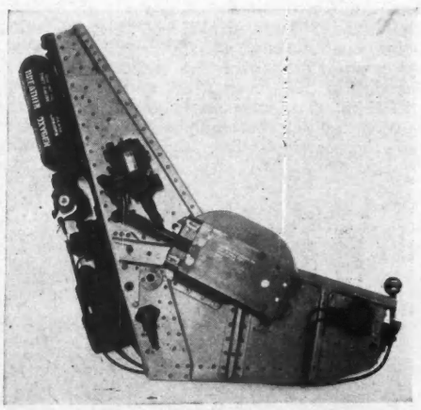
## Seat-Mounted Oxygen Regulator System

Designed specifically for use in modern high performance aircraft utilizing ejector seats is the Normalair seat mounted oxygen regulator system. This installation has the particular advantage that valuable panel space is freed for other controls and instrumentation.

Every component part of the system is mounted on the ejector seat including the regulator, which is the main item. During normal operation this regulator is supplied with oxygen from the main aircraft supply which may be stored in either gaseous or liquid form.

In the event of the pilot ejecting himself from his aircraft, an emergency cylinder of gaseous oxygen attached to the seat automatically comes into operation until the seat leaves him at a safe breathable altitude.

*Normalair Limited, Yeovil, Somerset.*



*Mounted entirely on the ejector seat, this system controls the main oxygen supply during normal flight and provides for an emergency supply during free-fall after ejection.*

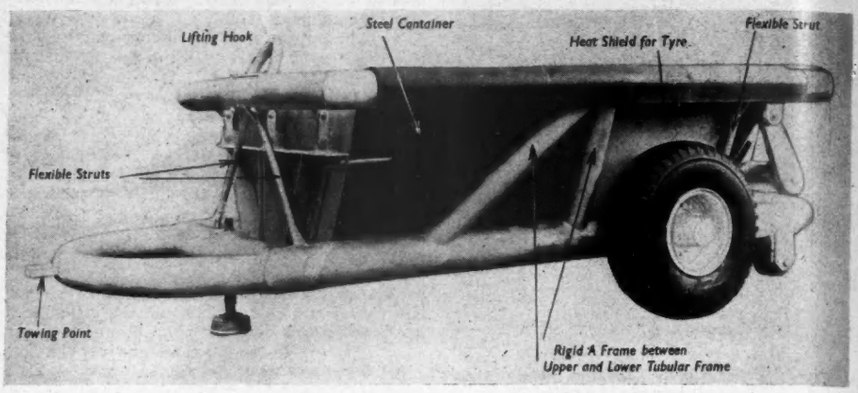
# Arduous Duties for Rubber Tyres

In the new plant of the Foundry and Engineering Division of Guest Keen Iron and Steel Works at Dowlais, Glamorganshire, ingot moulds and bottom plates are produced from three 8 ft inside diameter cupolas. These cupolas, which are probably the largest of their type in the world, present a problem in disposing of their red hot and molten contents at the end of the day's work.

Normal practice is either to drop the hot material on to sand on the foundry floor and quench it with hoses, with resultant fume and dirt in the foundry, or to drop it into a rail truck and take it away to quench. However, the nature of the site at Dowlais meant that the extra room required for rail layouts with their limited radii would have entailed costly excavations and GKIS asked their consulting engineers, W. S. Atkins and Partners, to devise an alternative solution.

The result was a two-wheeled pneumatic-tyred tubular-framed vehicle with a catenary container made up of $\frac{1}{2}$ in and $\frac{3}{4}$ in mild steel plate. This container is supported by being hooked over the top members of the chassis and is allowed to expand and contract freely, thus preventing the severe thermal stresses which would occur in a rigid design. The vehicle is extremely manoeuvrable and able to run on the concrete foundry floor propelled by a fork-lift truck which is used also elsewhere in the foundry.

The pneumatic tyres, which are Michelin G20Y type, partly filled with water, provide some resilience to cushion the impact of the load. This load, which consists of three to four tons of red hot sand and coke and maybe two tons of molten iron and slag, falls freely for about 8 ft. In spite of this extreme duty, which includes their catching fire almost every time they are used, the tyres last about nine months to one year.




*Pneumatic tyres help to take up the impact of the load discharged by the cupola. The tubular frame, and the freely hanging container, also help to minimize stresses under load.*

After quenching with water the load in the car sets into one large lump due to the molten slag and is emptied out by lifting the car from one end with a crane and turning it over on its back.

The car was constructed by International Combustion Limited, of London and Derby. *W. S. Atkins and Partners, 158 Victoria Street, London SW1.*

# Intercoolers Raise Engine Output on Locomotives

The first of a further 69 diesel electric locomotives, Type 2, for British Railways were recently handed over for service. Although generally similar to the previous Sulzer engined locomotives built by the Birmingham Railway Carriage and Wagon Company, they have an increased engine rating, due to the inclusion of an intercooler, and are fitted with GEC electrical equipment. Westinghouse brake equipment of a special lightweight design is another fundamental difference.

Geared for a maximum speed of 90 mph, the locomotives, in view of the importance of having the maximum power available at the higher speeds for operating passenger trains, have the transmission designed to absorb the full engine output up to 80 mph. As can be seen from the graph, the amount of engine unloading which occurs between 80 and 90 mph is not such as to significantly affect the performance of the locomotive.

The power unit is the Sulzer 6LDA28-B. This is the intercooled version of the pressure-charged 6 cylinder diesel engine with 280 mm bore and 360 mm stroke. It developes 1,250 bhp continuously at 750 rpm. The non-intercooled version of this engine is already in service in 198 locomotives and they develop 1,160 hp. The increase in output between the two versions has been obtained by a simple form of charge air cooling, the intercooler being incorporated in the cooling water circuit so that separate radiator elements and an extra pump are avoided.

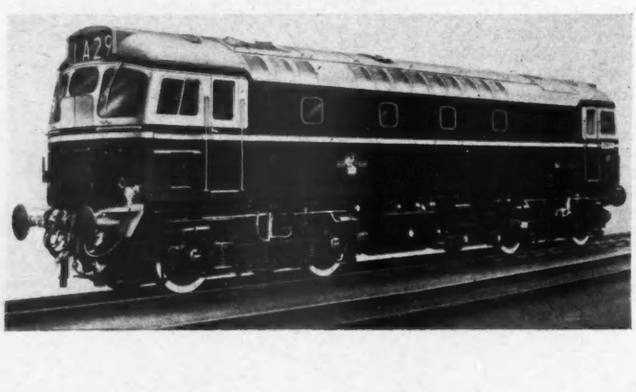
The intercooler for the "B" version is an air-to-water, three flow cooler with round tubes of flat fins, the latter enabling the whole volume within the cooler to be occupied by active surface. The tube stack is fitted directly into a wide part of the induction manifold between the pressure-charger and the engine, thus making the intercooler an integral part of the engine. Cooling water is derived from the main engine cooling circuit with additional piping, radiator and pumps.

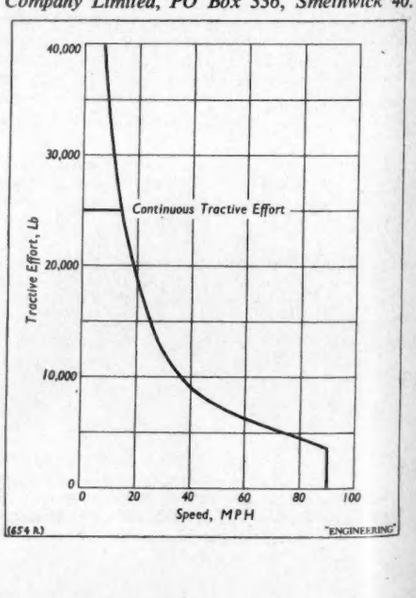
Both the main and auxiliary generator armatures are mounted on a common cast-steel hub, which is bolted solidly to the engine crankshaft flange, and is carried in a single roller bearing at the outer end. Advantage has been taken of the necessarily large diameter of the medium speed main generator, to partially recess the auxiliary generator into it and so keep the overall length of the set to the same figure as with the previous main generator, in spite of the increased output.

The four axle-hung 236 hp traction motors have the brush gear rotatable to enable servicing to be carried out from below the machines. An improved design of traction motor bellows has been fitted; quadruple springs have been incorporated that ensure the bellows remain in contact with the air duct at all times. This eliminates any possiblity of dirt entering the traction motors. Particular care has also been taken to ensure that there is no possibility of accidentally spilled oil from the interior of the locomotive penetrating to the underside of the underframe and thence into the traction motors.

Construction of the locomotive itself is generally of welded steel with the body sides acting as stress-carrying beams which, with the underframe, support the weight of the power unit and auxiliaries. The engine room has a translucent roof trap moulded in glass fibre reinforced polyester resin and fitted with quick-release fasteners to avoid any necessity for operating staff to work on the roof, thus avoiding any potential danger from overhead power cables. Good access is provided down each side of the locomotive as the engine has a central full width compartment.

*The Birmingham Railway Carriage and Wagon Company Limited, PO Box 336, Smethwick 40.*




*(Left) Though similar to previous Type 2 diesel electric locomotives, the inclusion of an intercooler on the engine has raised the engine output from 1,160 to 1,250 bhp.*

*(Right) In view of the importance of having maximum power available at the higher speeds for passenger train work, the transmission can absorb the full engine output at up to 80 mph.*

# Plain Words

*By Capricorn*

If you have ever stood on the deck of a ship as she leaves harbour for the high seas, and watched the groups of upturned faces as friends and relatives wave and smile with tears in their eyes, you will know that this is one of the most poignant of all human scenes. With the continuing growth in air travel, such scenes will become less common than they have been in the past hundred years or so—since the start of steamships. The new cheap air tickets to Ireland will even reduce the number of travellers on those familiar crossings of the Irish Sea.

I am used to change, but I shall be sorry if the switch from sea to air deprives us or our children of these so special occasions. Holman-Hunt's famous picture, "The Last of England," has a Victorian gloom and sadness about it which strike us—we are so hard-bitten—as almost indecently emotional, but few have souls so dead that they are not moved profoundly as they leave their own, their native land.

It is all the preparations for leaving by sea which play on our heart strings. As you go up on to "A" deck and lean over the rail, you experience an irrational but none-the-less real bond of sympathy with famous travellers of all time—the Pilgrim Fathers, Captain Scott on his last voyage to the South Pole, and the Greek sailors of the classics. Below you there is that ominous strip of black oily water between the ship and the quay. "All visitors ashore"—the command comes over the loudspeakers. A last-minute, skin-of-his-teeth traveller rushes aboard as the gangways are prepared for casting off. And then as the tugs take the strain, little children on the quay-side are held aloft to wave goodbye to their fathers, and old men wonder whether they will ever see their sons and daughters again.

In peacetime the experience is harrowing—heaven knows—but in wartime it is almost unbearable. Some of these men will indeed never see their families again. But they have already said goodbye to their families: the port of embarkation is secret, and so is the rendezvous with the convoy.

Years later, on a different troopship and with a different crowd of men, the lucky ones return. The military band is playing on the quay, banners of welcome are nailed to the sheds, the troops crowd along the rails drunk with excitement, and strong men grow weak as they search the upturned faces for those they hold dear.

It will be our loss if air travel takes all this away, and gives us instead the cold, clinical and mechanical atmosphere of the airport departure. In spite of the bustle of the airport, and the speed of the aeroplane, I find it rather soulless and depressing.

But perhaps aircraft will have an even shorter innings than steamships, and the groups of upturned faces will come back—as we leave the earth vertically in our rocket ships for travel by space.

## Letters to the Editor

### Water Tunnel 1,000 ft Below

Sir, You did well to conclude your Impact comment on the *Hydrological Survey of the Essex and Stour Basins* by inferring the necessity of a water grid (Engng., 25 Aug. '61, p. 225).

As you have allowed me generous space on this topic in your columns at various times, I can lay off for the moment special pleading for the Grand Contour Canal, and report objectively that there seem to be four distinct primary types of grid. These are the pipeline, the contour canal, the lined tunnel, and the deep unlined pressure tunnel in hard rock.

The last named would be a very interesting type facilitated by the fact that the Palaeozoic floor does not lie very far down, averaging about 1,000 ft, below eastern England, and the advantage would be in providing a pressure-retaining line to serve the upper downlands by gravity from distant high-lying catchments. The development of a sufficiently powerful tunnelling machine to do the work would be very interesting, but not, I think, in any way impracticable.

I am still, I believe, the only actual water grid promoter, but I am not jealous of any competition in this line, and would, in fact, be rather interested to see it.

Yours faithfully,
J. F. Pownall.

Cardiff.
26 August, 1961.

## Events in Advance

### Exhibitions and Conferences

Arranged in chronological order.

**Physics of Space Research, Residential Symposium.**—Wed., 20 Sept., to Fri., 22 Sept., at the Royal Military College of Science, Shrivenham, Swindon, Wiltshire. Apply to the Administration Assistant, the Institute of Physics and the Physical Society, 47 Belgrave Square, London SW1. Tel. BELgravia 6111.

**Radiospectroscopy of Solids, Conference.**—Thurs. and Fri., 21 and 22 Sept., in the Department of Physics, University College of North Wales, Bangor. Residential accommodation will be available. Sponsored jointly by the Institute of Physics and the Physical Society, and the British Radio Spectroscopy Group. Apply to the Administration Assistant, the Institute of Physics and the Physical Society, 47 Belgrave Square, London SW1. Tel. BELgravia 6111.

**Physics of Gas Discharge Devices, Conference.**—Thurs. and Fri., 28 and 29 Sept., at the Town Hall, Leamington Spa. Apply to the Administration Assistant, the Institute of Physics and the Physical Society, 47 Belgrave Square, London SW1. Tel. BELgravia 6111.

**Institute of Work Study, Annual Conference.**—Fri., 29 Sept., to Sun., 1 Oct., at the College of Aeronautics, Cranfield. Theme: "The Scope for Investigation into Office and Sales Procedures." Offices: 3 Cork Street, London W1. Tel. REGent 7669.

**Hydrogen in Steel, Conference.**—Wed., 11 Oct., to Fri., 13 Oct., at Harrogate. Organized by the Metallurgy Division, British Iron and Steel Research Association, 11 Park Lane, London W1. Tel. GROsvenor 4751.

**British Insulated Callender's Cables Ltd., Staff Conference on Work Study.**—Thurs. and Fri., 12 and 13 Oct., at Prescot, Lancashire. London office: 21 Bloomsbury Street, WC1. Tel. MUSeum 1600.

**Metallurgy of Beryllium, Conference.**—Sat., 14 Oct., to Mon., 16 Oct., at the Royal Commonwealth Society, Craven Street, London WC2. Organized by the Institute of Metals, 17 Belgrave Square, London SW1. Tel. BELgravia 3291.

**Northern Exhibition of Fuel and Power.**—Wed., 18 Oct., to Fri., 27 Oct., in the new Queen's Hall, Leeds. Sponsored jointly by the *Yorkshire Post* and the *Steam Engineer*, and organized by Modern Exhibition Services Ltd., The Queen's Hall, Sovereign Street, Leeds. Tel. Leeds 31961.

**Corrosion in the Nuclear Energy Industry, Symposium.**—Thurs. and Fri., 19 and 20 Oct., in Paris. Theme: "Corrosion of Sheath Materials." Being the 16th general meeting of the European Federation of Corrosion. Organized by the Société de Chimie Industrielle, 28 Rue Saint-Dominique, Paris 7e.

**British Institute of Management, National Conference.**—Tues., 24 Oct., to Thurs., 26 Oct., at Torquay. Offices: Management House, 80 Fetter Lane, London EC4. Tel. HOLborn 3456.

**Magnetism and Magnetic Materials, Conference.**—Mon., 13 Nov., to Thurs., 16 Nov., at the Hotel Westward Ho, Phoenix, Arizona, USA. Organized by the American Institute of Physics and the Institute of Radio Engineers. Apply to Mr. P. B. Myers, Motorola Semiconductor Products Division, 5005 East McDowell Road, Phoenix, Arizona, USA.

**Imperfections in Crystals, Conference.**—Fri. and Sat., 17 and 18 Nov., at the Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London SW1. Organized, as their autumn conference, by the X-Ray Analysis Group of the Institute of Physics and the Physical Society, 47 Belgrave Square, London SW1. Tel. BELgravia 6111.

### Russia's Plans for World Fair in 1967

Moscow has been chosen as the site of a new World Exhibition to take place in 1967. Organized under the auspices of the Russian Government, the exhibition will be dedicated to "Peace and Progress," and will be arranged in three sections, devoted respectively to the attainments of the Soviet Union, of other countries, and of international organizations.

Situated on a site between Moscow city centre and the Vnukovo Airfield, the exhibition will occupy an area of around 1,250 acres, or about two-and-a-half times that of the Brussels Exhibition. Motorways, tramways and two underground lines are to connect the exhibition with central Moscow.

Models of proposals for the layout of the large area involved have been prepared by members of the Moscow Research organization and the College of Applied Arts of the Institute of Architectural Design and are now on view at the Moscow Museum of Architecture.

### Meetings and Papers

**The address and telephone number of the headquarters of each institution are given at the end of this list. Meetings in the headquarters town are held there unless otherwise stated.**

**British Institution of Radio Engineers**

LONDON
"The New Graduateship Syllabus and the Institution's Recommendations for Practical Training." An all-day symposium arranged by the Institution's education and training committee. University College, Gower Street, WC1. Wed., 27 Sept., 10.30 a.m. (Admittance by invitation only.)

**Institute of Marine Engineers**

BELFAST
"Materials for Advanced Steam Conditions and Their Influence on the Operation of Marine Turbines and Boilers," by Commander H. E. C. Hims. Northern Ireland Panel. College of Technology, Belfast. Tues., 5 Sept., 6.45 p.m.

**Institution of Mechanical Engineers**

CHELMSFORD
"Lubricants in Nuclear Reactors," by P. E. B. Vaile. Eastern Branch Lubrication and Wear Group. Social Club of the Hoffmann Manufacturing Co., Ltd., Chelmsford. Thurs., 14 Sept., 7.30 p.m.

**Society of Instrument Technology**

BRISTOL
"Telemetry Installation in Bluebird, 1960," by A. Potten. Bristol Section. Department of Physics, University of Bristol, The Royal Fort, Bristol 8. Mon., 18 Sept., 7.30 p.m.

LIVERPOOL
"Instruments in the Phosphate Industry"; chairman's address, by D. G. Tate. Liverpool Section. The Merseyside and North Wales Electricity Board's Industrial Centre, Paradise Street, Liverpool. Thurs., 14 Sept., 7 p.m.

LOUGHBOROUGH
"Application of Instrumentation to Industrial Processes": one-day conference. East Midland Section. Loughborough College, Loughborough. Wed., 13 Sept., 9.30 for 10 a.m.

British Institution of Radio Engineers, 9 Bedford Square, London WC1. (MUSeum 1901)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London EC3. (ROYal 8493)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London SW1. (WHitehall 7476)
Society of Instrument Technology, 20 Queen Anne Street, London W1. (LANgham 4251)

# Ferguson Station Wagon for Safe Driving

*By Gordon Wilkins*

Harry Ferguson Research Limited have finally decided to start production of the long-awaited Ferguson car. The production model will be based on the luxurious station wagon prototype with 5/6 seats. It has been intensively tested and deliveries should commence in 1963.

The car incorporates all the ideas for safer motoring which were developed in the Coventry research organization under the direction of the late Harry Ferguson. It has four-wheel drive for maximum traction with freedom from skidding and wheelspin, and disc brakes on all four wheels controlled by the Dunlop Maxaret device ensure maximum braking efficiency on all types of surface without the risk of locking the wheels.

The fluid transmission is automatic and the all-independent suspension is aided by reducing the unsprung weight to a minimum by mounting all the brakes inboard on the chassis, and by using the new Armstrong hydraulic-pneumatic self-levelling suspension units instead of springs. Wear and tear on tyres and chassis is reduced by smooth traction from the fluid transmission and by the elimination of wheel locking during heavy braking. However, in one respect the present car differs from Harry Ferguson's ideals; it will be a comparatively luxurious and powerful vehicle with 5/6 seats, costing about £1,500 ex works, instead of the cheap peoples' car which he strove to produce. Use of four-wheel drive allows the engine to be placed at front or rear, to suit the purposes of the vehicle, but for this model, which is primarily a comfortable and fast road car with cross-country capability, the front engine has been adopted. It is considered to give the best weight distribution for good road holding and a large unobstructed platform area for a station wagon.

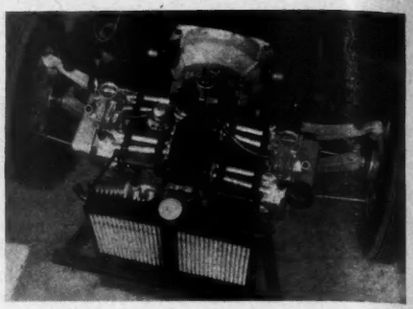
*5/6 seater Ferguson station wagon.*

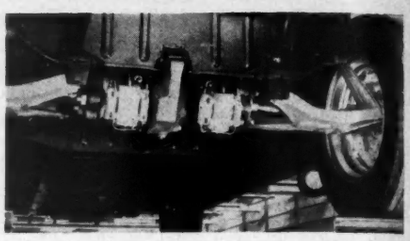
To reduce the overhung length to a minimum, experiments were made with H-type flat four engines consisting of two flat twin engines placed one above the other, using a Soanish yoke mechanism, or crankshafts geared together, but no easy solutions were found for the inherent design problems, and eventually a flat four of conventional shape was adopted. With a swept volume of 2·2 litres, 60 bhp has been obtained, with a maximum torque of 125 lb-ft and extensive use of light alloys for block and heads has kept the weight down to 250 lb (114 kg). The engine is hung ahead of the front differential but the automatic transmission is placed behind, and the drive is taken from the latter by a silent enclosed chain to the central master differential and then by light shafts forward and rearward to the front and rear differentials.

The fluid drive unit is the Ferguson-Teramals three-element torque converter designed to look after all normal acceleration hill climbing and cruising. If the driver needs extra torque for acceleration or hill climbing, a kick-down switches in the "plus gear," which consists of a reduction gear between the engine and torque converter. The master differential permits strictly limited speed difference between front and rear wheel in forward or reverse motion full details of the latest patent have not yet been revealed. It also allows one chassis-mounted Maxaret control unit to prevent locking of any one of the four wheels during heavy braking on slippery surfaces.

The suspension system consists of a single broad-based wishbone swinging through the same arc as the drive shaft to each wheel, supplemented by a single upper arm bearing against the end of the Armstrong suspension unit. This eliminates swing axle steering effects, keeps the camber changes low and ensures a high ground clearance. The chassis is a platform structure in sheet steel which gives a clean underside. The main structure stops at the front toe board where the abutments for the front suspension units are situated, and beyond this relatively light frame members project forward to carry wishbone pivots and support the radiator.

The production version will probably have four headlamps, and some of the sharp angles will be softened in the interests of safety. I am convinced, after extensive experience with various Ferguson experimental cars on road and test track, that they present an important breakthrough towards safer motoring.





*Flat four engine (above) develops 60 bhp. The front differential lies behind the radiator and the automatic transmission behind the engine. The rear differential and suspension is shown below.*

# French Governor for Diesel Fuel Pump

Précision Mécanique Labinal of Paris, manufacturers of the Silto single-plunger fuel injection pump, have incorporated a neat hydraulic governor in the pump body. Known as the "liquid stop" governor, it is claimed to give more flexibility, to be more accurate and less bulky, than mechanical, vacuum and other hydraulic governors.

The moving components of the governor comprise two spring-loaded ball valves, a shuttle piston, a spring-loaded cut-off valve and an adjustable needle valve; fuel is supplied under pressure by the pump piston.

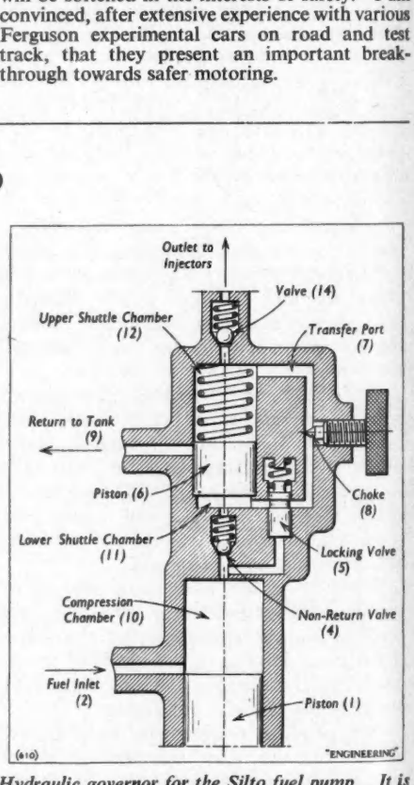
As the pump plunger (1) operated by the single-camshaft rises, it closes the fuel inlet (2). The fuel being compressed in the cell (10), lifts the locking valve (5) and the transfer port (7) is closed. As this occurs, pressure is transferred to the ball-valve (4) above the compression chamber and this valve, which is fitted with a stronger spring than the locking valve, opens, allowing fuel to pass through to the shuttle lower chamber (11).

Pressure of the fuel, transmitted by the pump plunger, overcomes the shuttle spring, until the shuttle uncovers the port (9) which feeds excess fuel back to the main tank. At this stage the pump cam is on top of its stroke, and as the plunger moves downwards, valve (5) opens. The ball valve (4) is forced back on to its seat by its spring, and the shuttle, under spring pressure from above, forces the oil through the open transfer port to fill the shuttle upper chamber.

Injection occurs on the next upward stroke of the pump plunger. The first cycle, just described, is repeated and as the transfer port is closed the fuel in the shuttle upper chamber is forced through the ball-valve (14) to the injector until the shuttle has moved far enough upwards to open the excess fuel port. As this occurs, injection is abruptly cut off. The whole sequence of operations limits the amount of fuel injected to that held in the shuttle upper chamber.

By adjusting the cross-sectional area of the transfer port with the needle valve, the downwards stroke of the shuttle can be controlled so that the pump plunger will start to rise before the shuttle has completed its stroke. This being brought into effect, the locking valve is closed, and the ball valve to the shuttle lower chamber opened. The pressure of fuel through (4) halts the shuttle and makes it start its upward stroke from a slightly higher point, so that the quantity of fuel delivered is less.

The manufacturer claims that the chief advantage of the system is that the amount of fuel injected is very accurately controlled according to the load and engine speed. The "liquid stop" shuttle is said to be very consistent in operation and between any two injections it returns to its previous position to within 0·01 mm regardless of engine speed.




*Hydraulic governor for the Silto fuel pump. It is claimed to be more accurate and less bulky than any other type.*

# Human Element

## Projected Cost Engineers' Association

AN organization of cost engineers is active in this country as a Regional Section of the American Association of Cost Engineers. Since last December, however, it has been the policy of this section, with the approval of its parent association, to seek to form an autonomous British organization, largely because a national organization would obviously be in a better position to earn and command the respect of British industry.

At the same time, though, a British organization would be able to obtain the benefit of American experience (and, of course, give in return the benefit of its own experience) by an arrangement with the AACE for having representatives on each other's national technical committees. Thus, there could be free and complete interchange of information between the two bodies.

Perhaps there is a danger of industry becoming fragmented into a multitude of organizations and associations but, if it will help to make engineers more and more cost conscious, this is one organization which would surely be of benefit to industry in this country. If, at the same time, its object would be to make accountants more and more engineering conscious, then such a body could have yet greater significance.

## Statement of Aims

The avowed aims of the AACE are (*a*) to promote through educational and scientific means the science of cost engineering; (*b*) to advance the science and art of cost engineering; (*c*) to provide forums and media through which experiences with the principles and techniques of cost engineering may be reported, discussed and published; (*d*) to promote standardization of terminology and where practicable develop standard methods, (*e*) to encourage the inclusion of cost engineering instruction in engineering curricula; and (*f*) to cooperate with other organizations having common or related objects. This statement of aims might require some minor translation for home consumption, but it is as laudable and economically necessary in this country as in the USA.

The British Regional Section of the AACE has already made a postal ballot among its members to ascertain whether there is a general desire to convert the section to an autonomous national organization. The results of the ballot will be made known at the next public meeting of the section, on 27 September; and, if general approval is in fact given, the machinery will be set in motion for the national body to be created at the section's next Annual General Meeting in April, 1962.

A drive is being made to increase membership in time for this change. It is appreciated, however, that some potential members would be prepared to join a national organization but would be less eager to be members of the present Regional Section during the interim period. Arrangements have therefore been made for such engineers to join the Regional Section as "Applicant" members, if they wish, on the understanding that no part of their section fee or their application form will be transmitted to the AACE.

Details of the Regional Section and of the projected national organization are obtainable from Mr. J. E. Cran, 28 Dulwich Wood Avenue, London, SE19.

## Industrial Education in France—

The nine members of the BACIE (British Association for Commercial and Industrial Education) West Midlands Regional Group who made a study tour in May of the French industrial education and training system have now made their report. It is of particular importance in view of our projected entry into the Common Market.

An early point made in the report is that state control of education is tighter in France than in this country, and includes the issuing of national syllabuses and courses of study and the equating of teachers with Civil Servants. Most French technical education is full-time and sometimes begins as early as eleven years of age, a time of life which seems to have even greater importance there than in our own system, for selection for courses takes place between the ages of eleven and fourteen and "failure to achieve the right success at the proper time would appear to be without redress."

Part-time and evening courses seem to be few and far between and do not carry much weight. The close liaison between technical institutions and industry which is demonstrated in this country by block release and sandwich courses is not apparent in France, outside private establishments.

These French students spend more time in the classroom than their English counterparts, but they spend more of this time in liberal studies—an obvious insufficiency in our own technical education. On the other hand, French students seem to spend more time in practical production work, and perhaps less on subjects requiring more intellectual effort. A further interesting point is that most of the full-time technical institutions have student hostels which help to create the atmosphere and advantages of residential education.

Apprenticeships begin after the school leaving age—at present 14 or 15, but later to be raised to 16—and are shorter than ours, lasting usually three years but sometimes two or four years. It is also possible for people of suitable schooling to take up an apprenticeship when they are older so that an opportunity missed at fifteen is not necessarily one missed for ever.

Vocational education administered by the government and by local authorities is free to the student (though this is not true of some higher educational courses) but the cost is partly met by an apprenticeship tax levied on all employers and paid, at the firm's discretion, to either a selected institution or the central authority. The report's observation on this tax—"It seems reasonable that any firm that requires skilled men but does not train them should be expected to pay its share of the national bill for training"—is one that would be supported by many English firms with up-to-date training who find some of their skilled men pirated by other less scrupulous firms.

From the report it is clear that there are fundamental differences between the French and English systems which will have to be gradually reconciled when we enter the Common Market. Entitled *Education and Training in France*, the report is available from BACIE at 7*s* 6*d* for members and 10*s* for non-members, with the usual bulk discounts.

## Aesthetics for Engineers

The Council of Industrial Design is holding two further design appreciation courses for engineers in October and November. Both will be residential and in the London area. The first and longer course will be held in two phases, from 23 to 27 October and from 20 to 24 November, and will aim to impart an appreciation of industrial design to draughtsmen and similar people and to senior apprentices.

During the first residential period of instruction, the course members will be lectured and instructed on design concepts, visual factors and ergonomics. They will also be introduced to ways of analysing design qualities, in preparation for the four-week period between lecture phases when they will carry out analytical projects in their own time.

When they return to the course for the second phase of lectures, students are to meet practising industrial designers and members of the CoID Industrial Division for discussion and comment on their homework projects. Reports on the ability and performance of course members will be made to their sponsoring firms and, where a student demonstrates design ability, recommendations for subsequent training will be made.

## For Management

The second course is to be for members of engineering management and will be held from 27 November to 1 December. It is intended to show the developing importance of design aspects in engineering, imparting an appreciation of design in its widest context, and putting forward methods of making design improvements.

Lectures will cover the development of industrial design, the influence of form and colour in engineering equipment, and—branching into ergonomics—the human factors in machine and equipment design. To demonstrate current approaches in design policy improvement there will be talks by people from manufacturing industry and industrial designers. It is suggested by the council that this should be of particular interest to technical directors, chief engineers and chief designers.

There is little doubt that courses of this sort are necessary for we tolerate too much ugliness and too much tawdriness in both our working and non-working lives. This is not just a question of aesthetics, though that is important in itself. It is also a question of producing the most harmonious, and therefore most productive, working and living environment.

However, in its mission of "bridging the gap between industrial design and engineering" the council is, one hopes, aware that the gap has to be bridged from both sides. In seeking to praise the design and appearance of a product or machine, it is necessary to bear in mind that it must still be functional and acceptable to the engineer—a point which has sometimes been missed in recent months. It is to be hoped that the current near-royal investigation of this problem will pay off.

## ILO Stresses Social Objectives

In summing up the 45th Session of the International Labour Office, held in July in Geneva, the Director-General, Mr. D. A. Morse, stressed the responsibility of the organization in keeping social objectives to the fore during the current period of rapid industrial change throughout the world. Referring to what he called the "two dynamic forces for change"—the drive for economic development and that for technological progress in production processes—he considered that the ILO has an important job to do in ensuring that social improvement remains an important consideration throughout the world against this background of flux.

The director-general, emphasising that the ILO must stand apart from the competing ideologies and concentrate on the practical aspects of its work, pointed out that economic, social and political objectives had to be weighed when resources were being allocated. Too often, he thought, when investment is made for economic development, production rather than employment effects are the primary consideration—in spite of the fact that growing unemployment was "building up an explosive force which could shatter the political foundations of the new regimes."

In this country, where industrialization and subsequent industrial change have evolved at a comparatively leisurely pace, we have learned—sometimes, unfortunately, after the event—that it is important to consider the social and human effects of industrial or technological change. This is an even more important factor in the under-developed countries which are in a state of hot-house political, as well as industrial, evolution, if not revolution.

## The Roads that Lead to Farnborough

Over a quarter of a million people are expected to visit Farnborough Air Display and Exhibition this month (4 to 10 September) and most of them will be travelling by road (how else?). To keep traffic flowing, the RAC are setting up over 800 of their familiar blue and white signs within a 25 mile radius of the display.

This is one of the largest operations handled by the RAC's signs department, and motorists are strongly urged to take advantage of the signposted routes since they have been carefully planned with the cooperation of the police and the local authorities. It seems that this is one occasion when the clever thing to do really is to follow the signposts.

The RAC will also have dozens of extra motor-cycle patrols and radio-controlled rescue vehicles in the area. Information officers will also be working on the airfield itself.

*Presidential Address to the Engineering Section of the British Association*

# Future Growth of World Communications

*By Sir Gordon Radley, K.C.B.*
*English Electric Company Limited*

**A system of round-the-world communications using trans-oceanic cables is now being built. For the future, space satellites carrying radio repeater stations offer almost unlimited prospects for expanding facilities.**

During the post-war years rapid growth in the facilities for world communication using transoceanic telephone cables has appeared as technically possible. Just recently this has been followed by proposals for radio repeater stations in space satellites providing cheap and unlimited communication facilities on an even greater scale. The subject has more than engineering importance. World communication systems in the past have largely been provided by British enterprise. Cable and Wireless own 150,000 miles of submarine telegraph cable—more than half the world's total mileage; the widespread nature of our Colonial and Commonwealth interests provided an incentive to build such systems. But the great sums of money American governmental and private enterprise is now able to invest in space research and in launching satellites must constitute a threat to British retention of the world communication business.

## North Atlantic Route

Most of the major engineering advances giving promise of improved communication have first been tried out across the North Atlantic. Notable events were the attempts, about a century ago, to lay the first transoceanic submarine telegraph cable; Marconi's transmission of the first long distance radio signals in 1901 and the completion of the first transoceanic submarine telephone cable system in 1956. The reason is the great concentration of traffic on this route. Excluding traffic to Europe, that from the United Kingdom to North America is between six and seven times that to all the rest of the world put together.

## Frequency Bandwidth

Better communication facilities usually require the use of an ever-increasing frequency bandwidth. The first transatlantic telegraph cable transmitted telegraph messages at a speed of only three words per minute. It did so within a frequency bandwidth of about 1½ c/s. The improved communication capacity of later transoceanic telegraph cables was made possible by their ability to transmit frequencies up to 100 c/s.

Speech requires the transmission of much higher frequencies. A modern transoceanic telephone cable will provide both-way paths for 80 telephone circuits, each path occupying a channel bandwidth of 3 kc/s.

Transmission of a television picture, using the existing British standards of definition with its accompanying sound, needs a 3·5 Mc/s channel. The higher standard of definition used by European television requires a bandwidth nearly twice this.

## World Communication System in 1956

Prior to 1956 world telegraph communication was provided by submarine cable and radio; telephone communication could be provided on radio only.

Propagation of the radio signals depends on reflection from the ionosphere which is very dependent on sun spot activity and for three or four years out of a regular solar cycle of eleven years, the reliability and communication capacity of radio links may vary very considerably. Moreover, in the high-frequency (HF) band which is the most suitable for long distance communication, the world total of frequency assignments between 4 and 10 Mc/s increased from 6,658 in 1929 to 74,284 in 1959. It is quite clear that radio alone cannot satisfy the growing needs for world communication.

## Coming of Transoceanic Telephone Cables

Long distance telephony over submarine cables only became possible with the development of underwater electronic repeaters for the periodic amplification of signals at regular intervals along the cable. At the highest frequencies transmitted in a modern multi-circuit telephone cable, the power of the signals is reduced by nearly a half after they have travelled a mile and this loss is logarithmic. The first repeater—a very cumbrous and crude affair by modern standards—was not submerged until 1943. It is still pleasing to recall that the operation was conducted by the British Post Office.

**In this and the next two issues, "Engineering" publishes papers read to the Engineering Section of the British Association, now meeting at Norwich. In all, nine papers will be published.**

The first transatlantic telephone cable was completed in 1956 as a tripartite venture between the American Telephone and Telegraph Company, the British Post Office and the Canadian Overseas Telecommunication Corporation. The section between Newfoundland and Nova Scotia, about 336 nautical miles, was of British design and construction. It has become the prototype for the cable being completed this summer between the United Kingdom and Canada (CANTAT), and will be the prototype of a number of planned systems, both British and American.

The distinguishing feature of the American designed part of the system between Newfoundland and Scotland—1,950 nautical miles—was the use of two cables, one for each direction of transmission. This facilitated the design of the electronic repeater which is basically a one-way device. It did, in fact, become possible to build one-way repeaters for this cable in long, pressure-resisting, but flexible, steel housings which constituted no more than a bulge of just under 2¾ in diameter in the cable.

In a system of this kind there must always be the fear of communication ceasing due to failure of one of the 303 valves and about 6,000 other components in the submerged equipment. This led to a policy of conservative design, with careful selection of components of well proved types. Inspection during construction was searching and repetitive. The policy has been justified by the absence of repeater faults, though the cable has been cut on a number of occasions by fishing vessels near the shore ends.

In the first transoceanic telephone cable system each repeater annuls the loss in approximately 38 miles of cable preceding it. It must do so at all frequencies transmitted. The importance of getting the conjunction of cable and repeaters right is due to the fact that the system works between comparatively narrow margins. If the incoming signal to a repeater is at too low a power level the margin between the signal and the system noise is reduced. Signal and noise are amplified together and this may be cumulative at successive repeaters. If, on the other hand, the signal after amplification is at too high a level, overloading may take place giving rise to cross-talk between channels. The effects are illustrated in a crude way in Fig. 1.

An important development has been the introduction of TASI (Time Assignment Speech Interpolation) on the transatlantic cable circuits. TASI dispenses with a pair of channels—one for each direction of speaking—reserved for each telephone conversation in the ocean cable. By means of an elegant electronic switching system, for which the Bell Telephone Laboratories were responsible, TASI connects each fresh burst of conversation to any idle channel in the group. At the distant end a steering signal connects this channel to the right listener. Provided the number of channels in the group is large enough, the number of conversations possible simultaneously is practically doubled.

## "Round-the-World" Telephone Cable System

(i) *Atlantic Section*

The cable laid during the summer between Scotland and Canada will form the first link in the projected Commonwealth round-the-world cable system. It is an entirely British achievement and is a distinct step forward in transoceanic cable technology. A single cable is used for both directions of speech transmission; the "go" and "return" channels being separated by the use of frequencies between 60 and 300 kc/s for speech in one direction and of frequencies between 360 and 608 kc/s in the other. At each repeater, the two sets of channels are separated by electronic filters so that all channels pass unidirectionally through the amplifier.

When both-way transmission can be obtained within the communication capacity of a single cable, it usually provides a cheaper system. The necessary transmission of much higher frequencies for a given number of circuits means that the distance between points of amplification must

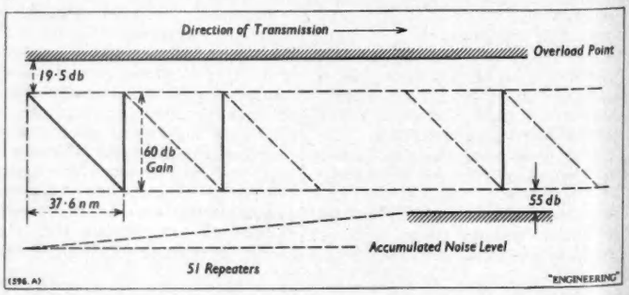



*Fig. 1 Signal level variation along transatlantic cable.*

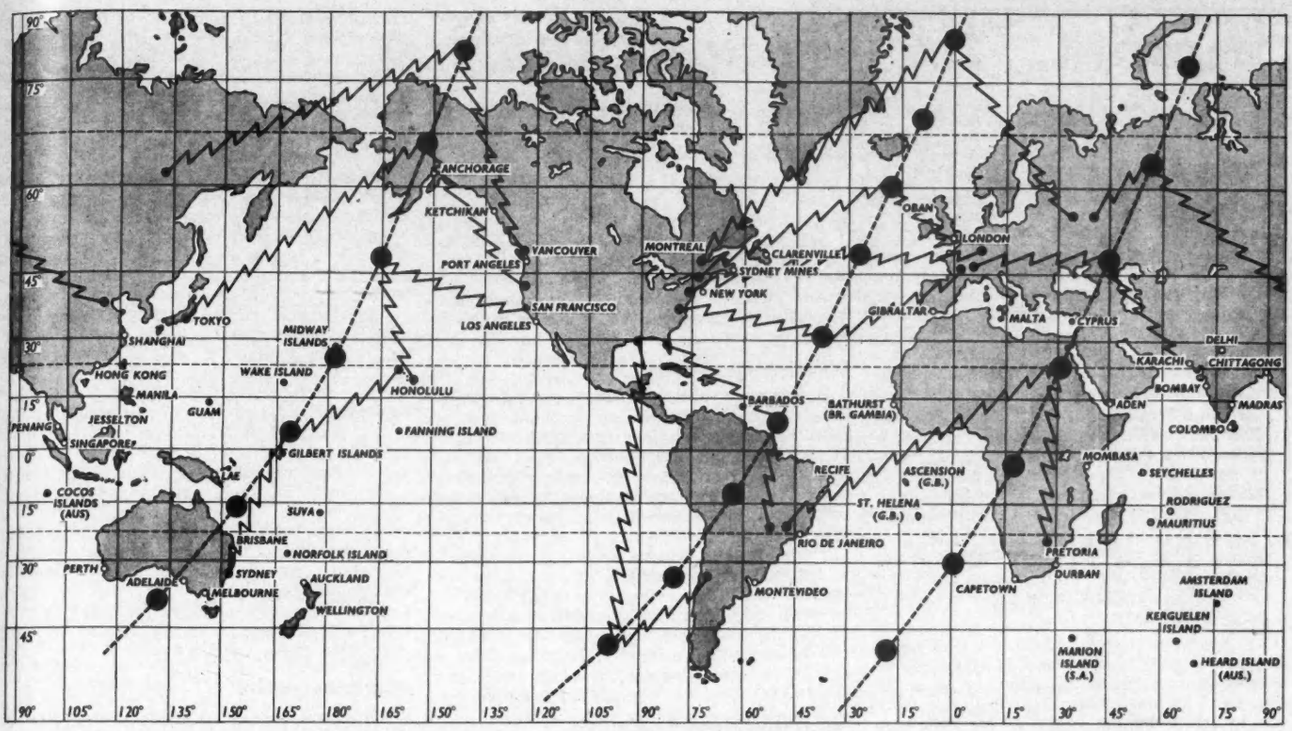



*Fig. 2 World-wide communications provided by a system of low-orbiting space satellites.*

be reduced and in the Canadian cable the repeaters are only 26 nautical miles apart. There are 89 under the water between Newfoundland and Scotland.

The filters which separate and subsequently re-combine the two directions of transmission add considerably to the number of components in each repeater and to the space which they occupy. This means that a comparatively large steel housing is required. The transfer of it from the ship to deep water has constituted a difficult problem. Unlike the flexible housings used for one-way repeaters, these large rigid housings cannot be made to follow the cable round a drum as part of a continuous laying process, but mechanical engineers have devised new types of laying machines to deal with this problem.

The Canadian project has made use for the first time in a major operation of a new type of deep sea cable. Unlike traditional designs this is not armoured, the protection given by armour being, in fact, quite unnecessary in deep water. The cable is given strength by a high tensile steel core which is torsionally balanced. The cable has the advantage of being more easily handled, no more expensive, lighter and of lower attenuation for a given overall diameter. Armour, of course, is still used in shallow water near the shore ends.

(ii) *Pacific Section*

The idea of a round-the-world cable of high traffic capacity began to take shape at a Conference of Commonwealth representatives in London in the summer of 1958. The conference recommended a round-the-world cable system providing a measure of alternative routing in case of breakdown. When completed the system would provide telephone, telegraph, picture telegraph and telex facilities between the countries where it lands and to other countries by short radio spurs. The conference estimated that manufacture and installation of the system would be practicable within a period of not less than about 10 years without undue difficulty.

Planning for the Pacific section of the round-the-world cable is well advanced. This will provide transmission bands 240 kc/s in width in each direction over the sections Vancouver-Auckland-Sydney.

The cable to be used will be of the same construction as that just laid to Canada and the both-way repeaters will be similar in design to those used on the Canadian project. There will be 317 between Sydney and Vancouver.

A landing in the Hawaiian group of islands is planned; this will provide a convenient point for interchange of traffic between the Commonwealth system and an American East-West route across the Pacific.

## Transistor Amplifier

One of the greatest difficulties in constructing a very long underwater section is the supply of power to the repeaters. Present practice is to energize them in series by a direct current fed along the centre conductor together with the high frequency speech currents. A total driving voltage of about 4,000 is required for the 51 repeaters in each of the first transatlantic cables between Newfoundland and Scotland. It is arranged so that the centre conductor of the cable and all the connected apparatus in the repeaters is 2,000 volts positive to the sea at one end and equally negative at the other. Repeaters could certainly be adopted for 6,000 volt working, and even higher voltages might be practicable inside a rigid housing of the dimensions used for the Canadian project.

The use of transistors instead of valves would, of course, greatly simplify the power feeding problem. Very rapid progress is being made in transistor technology and it is possible that the first transoceanic cable with transistor amplifiers is not many years distant.

Transistor amplifiers will be necessary in a long cable to transmit television. The frequency bandwidth required for such transmission is such that the repeaters will have to be very close together and it would not be practicable to design a system, say, 2,000 miles long using valves.

## Artificial Satellite

The artificial satellite which engineers propose to use as a means of expanding world communications will act as a repeater station in space, having a line-of-sight path to the earth stations with which it communicates. Because radio communication will no longer depend on reflection from the ionosphere it will be possible to use that part of the radio spectrum between about 1,000 and 10,000 Mc/s. This has a communication capacity several hundred times that of the HF band at present used.

### Passive Satellites

The most elementary form of communication satellite consists of a simple reflector travelling round the earth at a height of a few thousand miles. President Eisenhower used a satellite of this kind to deliver a Christmas message in 1958. A more serious test of the feasibility of relaying radio signals over long distances, by "bouncing" them from passive reflecting surfaces, was made in 1960 when the United States National Aeronautics and Space Administration (NASA) put a 100 ft diameter metallized plastic baloon into orbit at a height of about 1,000 miles.

Even when highly directional antennas are used on the ground, only a very small proportion of the energy radiated by the transmitter will hit a passive satellite and an even smaller part will be reflected back and dispersed over the earth's surface. For this reason active satellites are more likely to be used for communication

*Fig. 3 Steerable dish antenna, built by the Marconi Wireless Telephone Company.*

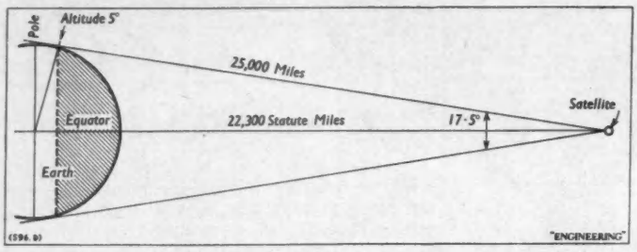



*Fig. 4 Geometry of synchronous satellite system.*

purposes. They will contain electronic repeaters which will amplify the received signals before re-transmitting them back to earth.

**Active Satellites**

The kinds of active satellite which have been most discussed are:—

(1) Satellites in circular orbits at heights between 2,000 and 6,000 miles. Each will complete a circuit of the earth in 3 to 8 hours and appear to move fairly rapidly across the sky. A number will be required so that at least one is always visible to both terminal radio stations.

(2) Satellites in circular equatorial orbits at a height of 22,300 miles. At this height a satellite makes one rotation every 24 hours and therefore appears stationary relative to a point on the earth's surface.

An American proposal of the first kind would employ 50 satellites at a height of 3,000 miles to provide world-wide communication as shown in Fig. 2. The satellites are divided into three sets in orbits making angles of 60° with each other. A variant of this, suggested in the United Kingdom, is for the use of satellites in elliptical orbits with perigees 300 miles high and apogees from 10,000 to 12,500 miles. Provided the orbits can be maintained in their relative angular positions, 12 satellites would provide complete global coverage.

All low-orbiting satellites, active or passive, require steerable transmitting and receiving antennas on the ground which can be continuously directed on to them. Dishes, 60 ft to 80 ft in diameter, will probably be used. Fig. 3 is a photograph of a British antenna of this kind. In a commercial system these would have to be duplicated at each ground-station to prevent interruption of communications during the period when one satellite is beginning to pass out of view and another taking its place as the communication link. Because of the, desirably, very narrow beamwidth of the ground station steerable antenna, automatic tracking of the statellite will be necessary. This will be controlled by a signal returned from the satellite.

The second kind of proposal, which makes use of satellites with an orbital period of 24 hours, has a number of obvious advantages. At this height, a satellite will " look at " nearly half the earth's surface, as shown by Fig. 4, and only three such satellites would be required to provide for communication between any two points on the earth's surface.

Because the satellite will remain stationary relative to the transmitters and receivers with which it communicates, the design of the ground station equipment is simplified. On the other hand, the distance of about 45,000 miles which the radio signals have to traverse in a trip, ground-satellite-ground, introduces a delay of 240 milliseconds into their transmission, or about a half-second before a reply can be received. For the transmission of telegraphy, data, television and many other kinds of communication, this delay does not matter but communication engineers are as yet uncertain whether delays of this order would be troublesome in a telephone conversation. Such a delay is appreciably longer than the 150 milliseconds which will be encountered on the longest wire line yet planned: the United Kingdom to Australia via trans-Atlantic submarine cable, thence across Canada by microwave and onwards by trans-Pacific submarine cable via New Zealand. But to reach Australia via a space system would require two 24 hour satellites with an intermediate ground station. This would bring the round trip delay to nearly one second which certainly would be serious.

**Satellite Power Sources**

Power to operate the electronic equipment in an active satellite will be obtained initially from the sun, though the long-term development of lightweight nuclear sources must not be ruled out. Much work has been done during the last five years on the development of the solar cell, principally by the Bell Telephone Laboratories in the United States.

The solar cells may be supported on " sails " at the sides of the satellite, extended after the satellite has settled in its orbit. They will have to provide an area of one or two square yards in order to generate enough power to operate the radio transmitter. During the time that a satellite is in the shadow of the earth, power will have to be supplied from storage batteries.

**Satellite-to-Ground Transmission**

Satellite communication systems will make use of frequencies in the same part of the spectrum as entirely ground-based radio-relay systems. But the distance between relay stations in a land system is usually about 40 miles, compared with 4,000 or much more to the satellite. Moreover, on land, highly directional transmitting and receiving aerials enable signals to be beamed from station to station. Highly directional aerials are almost impossible to arrange on a satellite and, to make use of any directivity, it is necessary to maintain attitude control of the satellite.

Taking both the increased distance and the lack of directivity together, the transmission loss between a communication satellite and its ground station may be 80 db—100 million times on a relative power basis—greater than the loss between two adjacent stations in a land radio relay system.

The problem is not serious in the direction ground-to-satellite because high transmitting powers can be fed into large parabolic antennas directed on to the satellite. It *is* serious in the other direction because the power of the transmitter in the satellite is limited to 1 or 2 watts and the signals it sends out are dispersed over a very large part of the earth's surface.

Amplification of these weak signals by means of a device which itself has very low intrinsic noise is the nub of the problem. Because of the thermal agitation of its molecules, every element of an electrical circuit produces spontaneous unwanted noise signals at radio frequencies. It has become common to measure this noise in terms of the equivalent temperature of its source; for a conventional amplifier this may correspond to 3,000° K. The invention of the maser provided the engineer with low-noise amplifying devices of a new kind. Taking advantage of the principles of quantum mechanics a very weak incoming signal is able to trigger a great amount of power over a limited frequency range. The problem generally is to extend this range, but masers have been constructed with a frequency coverage adequate for a satellite communications system. An effective noise temperature as low as 20° K has been achieved using a maser receiver in conjunction with the large horn antenna shown in Fig. 5.

**Modulation Methods**

The economics of satellite communication suggest planning in terms of at least 600 two-way telephone channels, or one two-way television channel. It remains necessary to mention the way in which the messages will be impressed on the radio signal. Information theory indicates that, by increasing the transmitted frequency band, it is possible to improve the signal-to-noise ratio without increasing transmitter power. Frequency-modulation is a technique frequently used for this purpose. Pulse-code modulation, in reality a method of processing information before applying it to any type of radio transmission, has many attractions. The important feature of both is their relative freedom from interference, but fairly wide band widths are required and it is likely that at least 250 Mc/s will be needed by each satellite system for two-way communication on the scale envisaged.

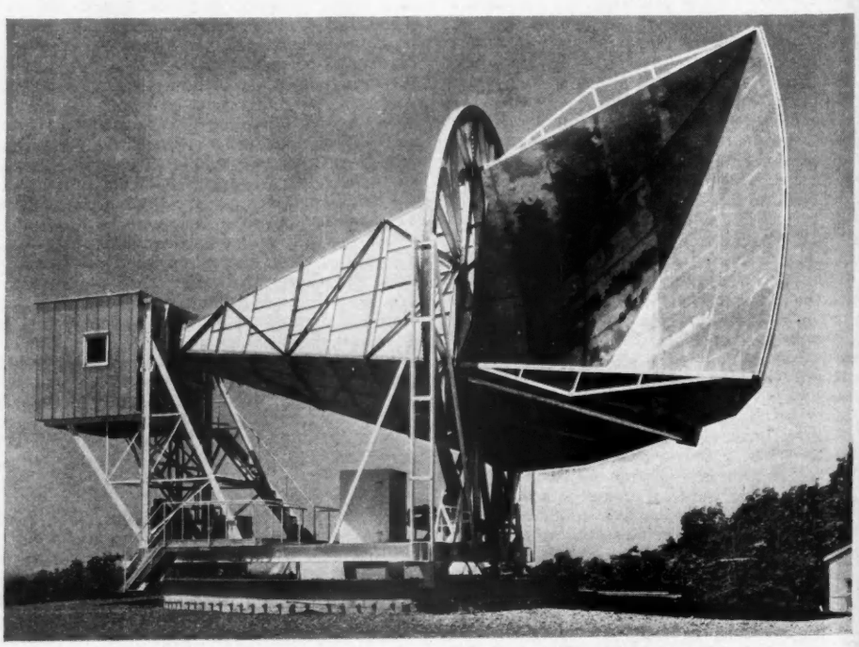


*Fig. 5 Horn-reflector antenna built by the Bell Telephone Laboratories.*

# Stator-Fed Variable-Speed AC Motors

**Stator-fed ac motors with induction regulator control are being built with outputs up to several thousand horse-power and speed ratios as high as ten to one. Such characteristics give them applications throughout engineering.**

*By J. C. H. Bone, B.Sc.(Eng.), A.M.I.E.E., A.M.I.Mech.E.*

*Laurence, Scott and Electromotors Limited*

It is unfortunate that the squirrel cage induction motor, which is by far the most widely used ac motor, is inherently a constant speed machine. The speed of such a motor is normally very closely tied to that of its magnetic flux, which rotates at a fixed " synchronous " speed depending only on the supply frequency and the number of poles for which the machine is wound. Frequency converters for varying the supply frequency to an induction motor tend to be complicated and expensive, though a frequency converter will be described (based on a simple modification to the variable speed motor) which is widely and successfully applied to control of the speed of groups of induction motors.

Two or more distinct speeds can be obtained from induction motors by the use of separate windings, each wound for the appropriate number of poles (or by the use of special types of single windings capable of reconnection). Such machines cannot, however, be considered as true variable speed motors as they are only capable of operating at a fixed number of speeds. Additional inefficient and sometimes costly apparatus is therefore necessary to enable the output of the driven machine to be controlled in the intervals between the fixed speeds of the driving motor.

As the speed of dc machines can be varied comparatively easily one solution is to convert from ac to dc by means of a Ward-Leonard set, or by the use of rectifiers. Such solutions, which fall somewhat outside the scope of this paper, are on the whole found to be both complicated and expensive.

Speed variation should not depend on the deliberate introduction of losses into the system as it does, for instance, with slipring induction motors or with equipments using an equivalent solution, such as hydraulic or magnetic slip couplings. Speed variation needs to be obtained without substantial sacrifices in efficiency as it will very often be necessary, on strictly economic grounds, to offset an inherently higher initial cost against a reduction in running charges.

Inherent limitations to the outputs for which equipments can be economically built—limitations to the supply voltage level, speed range or type of enclosure—must not be such that the field of application of any particular variable speed equipment is so restricted that the actual numbers of machines produced are insufficient to warrant the allocation of sufficient technical and commercial study to ensure continuous progress. Additionally, and possibly of even greater importance, the detailed electrical and mechanical design must ensure reliable operation for long periods with the minimum of specialized maintenance; however attractive an equipment may appear, it will not gain wide acceptance if its use entails undue allocation of time by operating or maintenance personnel.

Paper read before the Engineering Section of the British Association at Norwich, August 1961.

The basic requirements mentioned above are very largely fulfilled by the equipment upon which it is proposed to concentrate attention, the stator-fed variable speed ac motor with induction regulator control, which covers probably the widest field of any variable speed ac equipment. It is available in outputs of from one to several thousand horsepower, with speed ranges covering the complete field from the very narrowest ratios to more than ten to one. Such a machine is shown in the exploded view, Fig. 1.

## Basic Theory

As already mentioned, the induction motor is essentially a constant speed machine. However, if the resistance of the rotor is considerably increased it will run appreciably below its synchronous speed, though the extra losses so incurred would result in excessive heating within the machine. Replacing the squirrel cage winding of the rotor by a winding connected to slip-rings enables external speed regulating resistances to be connected to the rotor windings, so that the resistance of the rotor circuit, and hence speed, can be controlled. The losses are still large, but as they now occur in the external resistances they can be more easily dissipated. This method of speed control is clearly inefficient, particularly at low speeds since, for example, to run at half synchronous speed the losses in the resistances are equal to the output of the machine, so that efficiency at this speed is less than 50 per cent (Fig. 2a).

The overall efficiency would be vastly improved if the resistances, which dissipate the power as heat, were to be replaced by apparatus capable of absorbing the necessary energy and feeding it back into the supply. This energy is, however, at a voltage and frequency which varies with the motor speed so that a direct connection between the motor sliprings and the constant voltage constant frequency supply system is not feasible without the introduction of a variable voltage transformer and some form of frequency convertor.

In the stator-fed variable speed ac motor the return of energy to the supply is accomplished by the use of a commutator (automatically converting the variable rotor frequency to the constant supply frequency) and an induction regulator (providing the link between the rotor voltage which varies with the motor speed and the constant supply voltage). Energy can, therefore, be exchanged between the motor rotor and the supply so that the variation in motor speed is obtained without the introduction of major losses (Fig. 2b). This is a true exchange of energy as it is not restricted simply to returning energy to the supply but is also capable of drawing energy from the supply and feeding it into the rotor, under which conditions the motor will run above its synchronous speed. This is in contrast to many of the other systems, particularly those employing rectifiers, which inherently limit the transfer of power to one direction only. A reversal in the direction of power flow through the motor is also possible; that is, the equipment can act as a generator, absorbing power from the drive and feeding it into the supply.

A very large variable speed motor, built to drive circulating pumps at Uskmouth power station, is shown in Fig. 3.

In the earliest ac variable speed motors to gain wide commercial acceptance (the rotor-fed, or Schrage, type) the functions of motor and regulator are combined within a single unit. These machines, however, suffer from certain inherent limitations (for instance, to the output per unit, speed, supply voltage, etc.) which have had the effect of limiting their usage to machines with comparatively small outputs.

## Commutation

The principles upon which both stator and rotor-fed machines can be built have been known for many years but progress has been limited by the absence of any adequate solution to the basic problem of commutation. As a result, equipments have been limited to machines with low outputs per pole. Large outputs could therefore only be obtained by the expedient of designing machines with very large numbers of poles, i.e. the motors were limited to low speeds and hence tended to be both expensive and inefficient. The problem of commutation was solved in dc machines by the introduction of interpoles, but unfortunately this technique was difficult to apply to ac machines—where the problem is, anyway, inherently more difficult—because, in addition to the normal " reactance " voltage due to the self-inductance of the coil opposing any change (or commutation) of current, there is present an additional voltage between the commutator segments (" transformer " voltage) due to the main field which must also be handled by the brushes.

The magnitude of this transformer voltage plays a vital part in the design of all ac commutator motors, setting the ultimate limitation to the size of any particular type of machine which can be built. The transformer voltage of the stator-fed machine falls from a maximum value at standstill to zero at synchronous speed and then rises as the speed is further increased, whereas in the rotor-fed machine it remains constant at the standstill value irrespective of speed. As the limit in permissible transformer voltage is set by the running rather than the standstill value, stator-fed machines can therefore be built in much larger sizes than rotor-fed machines, particularly if the speed range is narrow.

The current in the coils of the rotor winding connected to commutator segments on either side of a brush are different so that, as segments pass across the brush face, the currents in the corresponding coils have to change rapidly. The self-inductance of the coils gives rise to the reactance voltage which opposes, and hence delays, the current change which, if not completed by the time the segments leave the brush, will force the current to arc across the gap between brush and segment; that is, the brush will spark. Commutation can be improved by increasing the resistance of the circuit during commutation (by

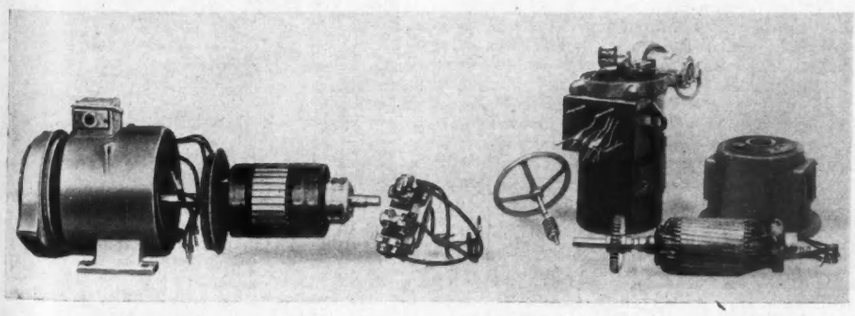


*Fig. 1 Exploded view of a medium-sized stator-fed motor with its induction regulator.*

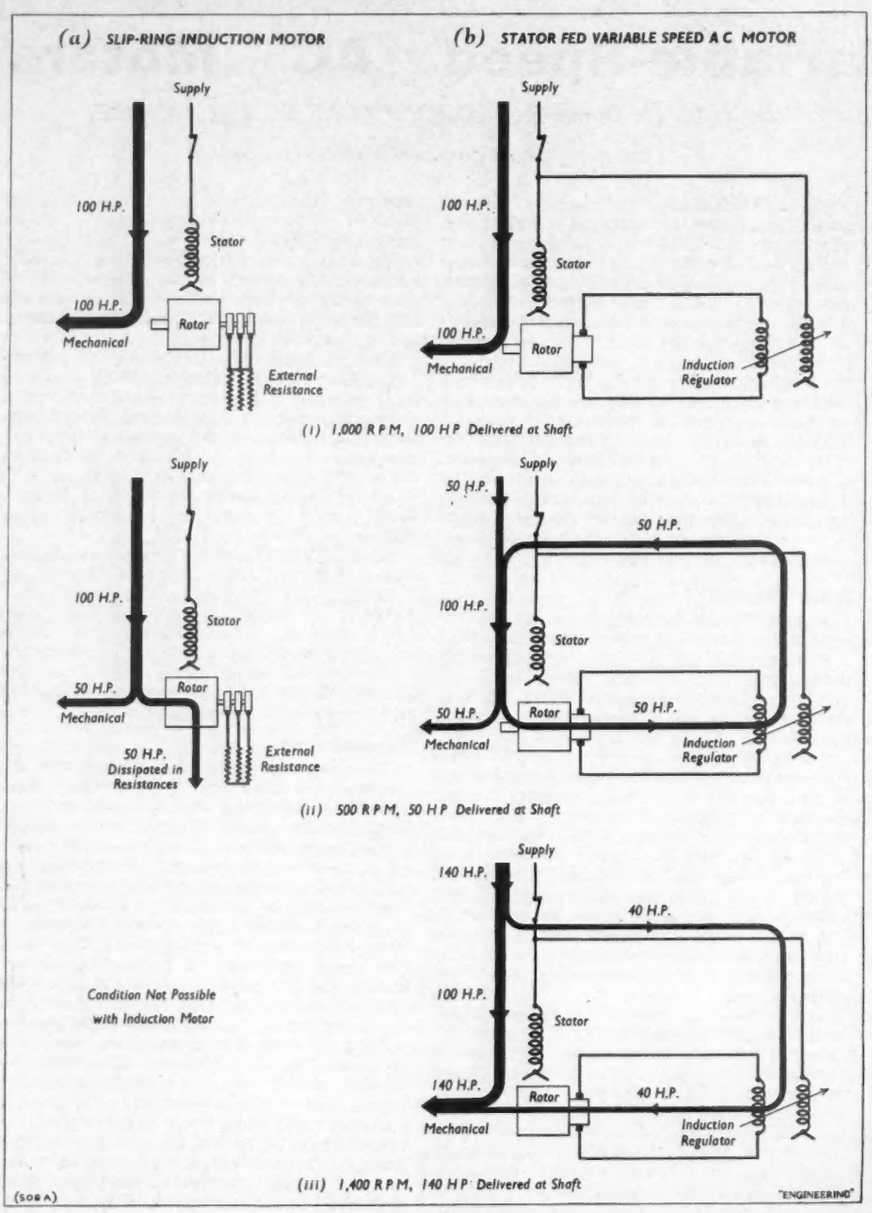



*Fig. 2 Power flow diagrams for (a) slipring induction motor and (b) induction regulator controlled variable speed ac motor (synchronous speed = 1,000 rpm), showing the limitations of the former.*

the use of high resistance connectors between windings and commutator) or by the use of high contact drop brushes, but these features are only partially effective. More successful solutions provide low impedance paths for the current in preference to arcing between brush and segment. These take the form of an auxiliary rotor winding connected in parallel with the main rotor winding and providing a discharge path for the energy of commutation. For such windings to be fully effective they must have a low impedance, a difficult if not impossible problem for conventional windings embedded in the iron circuit of an electric machine.

A highly successful method of reducing the effective impedance of the windings to the coil undergoing commutation is by the use of the well known fact that the impedance of a choke coil is substantially reduced by the addition of a short-circuited secondary winding (the impedance then falls from that corresponding to the magnetizing current of a choke to that corresponding to the short-circuit current of a transformer, which may be in the ratio of several hundred to one). To do this, main and auxiliary windings are separated by iron strips (Fig. 4) so that the auxiliary winding conductors are closely linked magnetically through the iron strips with adjacent conductors connected to main winding turns not at the moment undergoing commutation but linked in a similar manner with other main and auxiliary turns.

This "transformer" coupling between coils, for the purposes of commutation, results in practically all of the rotor winding coils being effectively connected in parallel to the coil being commutated. They act as an effective short circuit and hence reduce the impedance of the system to a very low value. Such windings absorb the whole of the energy of commutation (which would otherwise have been dissipated in the form of sparking at the commutator) and deliver it by transformer action to other turns lying in slots not at that moment undergoing commutation.

The use of such windings makes it possible to build machines with high outputs per pole while still retaining the very high standard of commutation which engineers necessarily expect from all modern commutator motors whether dc or ac. This feature is available throughout the range of outputs enabling such machines to be generally available at higher speeds, and hence smaller sizes.

## Brushes and Brush Gear

The successful collection of current from a commutator is to a large extent dependent on obtaining (and retaining) a suitable commutator surface or "skin." On normal machines this skin builds up naturally to the familiar chocolate brown coloured surface which engineers have learnt to recognise as a sign that the machine is functioning satisfactorily. Difficulty in obtaining or retaining a satisfactory skin can have many causes, such as poor commutation, wrong brush grade or the presence of corrosive or abrasive dusts in the commutator cooling air.

Vibration, which destroys the intimate contact between brush and commutator, must also be avoided. Unfortunately, a certain amount is inevitable because of the minor irregularities in the commutator surface, and brush gear must therefore be designed with a view to mitigating its effect as far as possible. To assist commutation, ac commutator motors tend to have thin brushes which have little intrinsic mechanical stability, and the necessary stability must therefore come from the brush holders themselves. Typical of such brush holder designs is the "reaction" type, shown in Fig. 5, in which the forces acting on the brush are arranged to ride up against one of the brush box faces. If for any reason the brush is disturbed, it is constrained by the design of brush holder to return to exactly its original position relative to commutator and brush box, and thus minimize the disturbing effect of commutator irregularities on the riding of the brush. The importance of retaining a suitable brush contact surface explains the superior performance of machines which operate with a fixed brush position when compared with the adjustable brush gear of the rotor-fed machines, where brush contact surface is inevitably disturbed whenever the motor speed (and therefore rocker position) is adjusted.

Many of the drives which require large variable speed motors are of the type which need to be run continuously without shutdown for very long periods. It is, for instance, usual to expect power station draught fans to run continuously between boiler overhauls which may, with modern boilers, necessitate running for 12 to

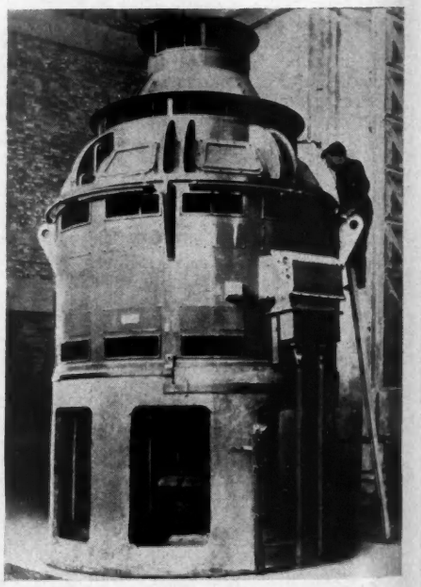


*Fig. 3 A 2,400/1,050 hp, 450/345 rpm vertical spindle motor, one of four installed at a British power station, and believed to be the largest ac commutator motors ever built.*

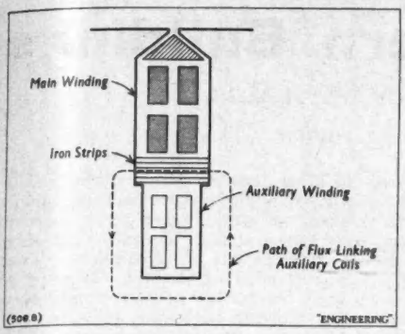



*Fig. 4 Cross-section through a rotor slot showing the use of iron strips to provide a path for the flux linking adjacent auxiliary winding coils.*

18 months. The brush life of variable speed motors associated with such boilers must, therefore, exceed the interval between boiler shutdowns, otherwise there is a risk of large and important units being taken out of service simply to replace brushes, a situation which would be clearly unacceptable.

Good commutation combined with a proper attention to the mechanical design of the brush gear and commutator enables stator-fed machines to be made giving consistent brush lives of between 8,000 and 12,000 hours, a brush life which would in the past have been regarded as difficult to reach even with conventional dc machines. With brush lives of this order the arguments against the use of commutators and brushes, on the grounds that they may represent a limitation to the reliability of the equipment, are clearly largely eliminated and the call for "brushless" variable speed ac motors ought, therefore, to be confined to those few applications where for special reasons commutators cannot successfully be used.

## Induction Regulators

The function of the induction regulator associated with the stator-fed motor is to provide an output voltage which, though variable in magnitude, remains substantially constant in phase. Such an output is obtained from a double induction regulator, which consists of two identical units coupled together electrically and mechanically. By suitable interconnection of the windings the output voltages of the secondary windings of each unit can be arranged to add vectorially, so that as the regulator is displaced from its neutral position the output voltage varies from zero to maximum. Such a regulator is a simple static piece of apparatus without sliding contacts, and its inherent reliability is therefore very high.

A double induction regulator is frequently replaced in modern designs by one of the many available single induction regulator connections. Typical of such equipments is that shown in Fig. 6 where the single induction regulator stator and rotor windings (connected in series) are fed from the secondary of a conventional transformer. Adjustment to the regulator rotor position, by altering the angle between stator and rotor voltages, controls the magnitude of the output voltage appearing between the centre tap on the transformer secondary winding and the junction between regulator stator and rotor windings. The voltage across the individual regulator windings, and hence the regulator flux, fall to a minimum when the regulator is in a neutral position, so that the losses drop as the regulator output is reduced. Among the other advantages of this regulator connection is the facility to "overturn" the regulator beyond its normal operating range to obtain higher outputs for short periods, for instance, for setting up or starting purposes.

A simplification to this connection is obtained by replacing the regulator transformer by an additional winding accommodated with the motor stator windings, which provides the feed to the regulator. Interchange of power between

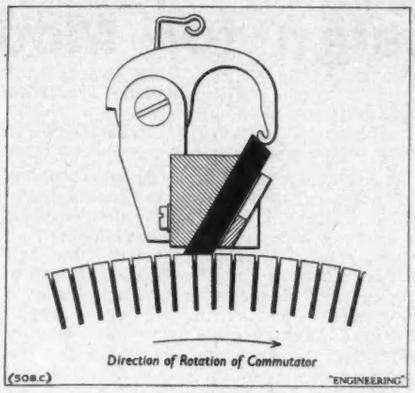



*Fig. 5 Sketch of reaction type brush gear. Bevelled brush top and 30° reaction angle constrain the brush to ride against the brush box body.*

regulator and supply is obtained by transformer action between this winding and the normal motor stator winding.

## Applications

Engineers in industry and those associated with public utilities are increasingly aware of the great advantage of a variable speed motor whose speed can be controlled in accordance with the exact requirements of the driven machine, and large numbers of these machines are used for the drive of fans and blowers, centrifugal and reciprocating pumps, machine tools, textile, paper and cable making machinery, rubber and plastics processing machines as well as having been installed in numerous drives in the chemical and allied industries.

In many of these drives speed variation is required to suit day-to-day variations in demand for the product being processed. In simple installations manual speed control is common but in the larger and more complicated installations various forms of automatic speed control are commonly employed to control the speed accurately in sympathy with the specific requirements of the drive. Fig. 7 shows a simple manually controlled machine.

The output of a centrifugal pump can be controlled by the use of throttle valves but the losses in the valve can be high and as a result it is not surprising that very large numbers of variable speed motors are used by water and sewerage works for the drive of pumps whose output needs to be varied. Such drives may very well run for long periods at reduced speed and it is, therefore, of particular importance that the efficiency of the driving motor should remain high at these reduced loads and speeds. To

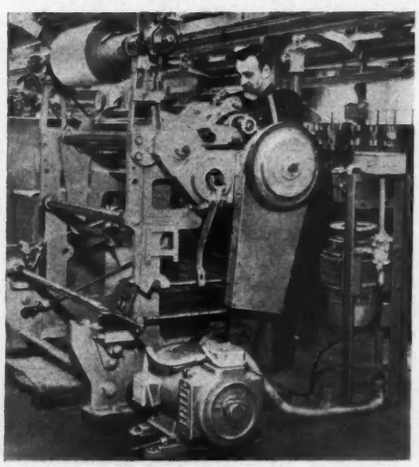


*Fig. 7 Direct-on starter and air-cooled hand-operated regulator controlling a small variable speed motor, mounted near operator's position.*

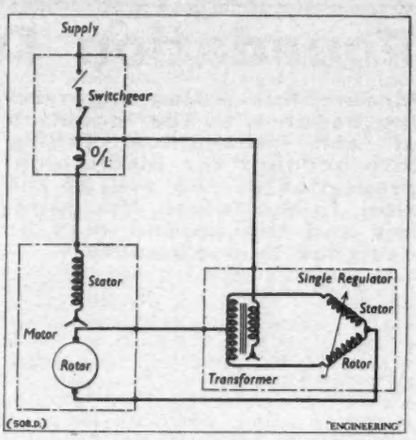



*Fig. 6 Line diagram of stator-fed motor with single induction regulator control (only one phase is shown).*

maintain optimum efficiency under these conditions it is desirable for the motor iron loss to fall as the speed is reduced. One method of doing this is by the use of an additional transformer fed from the induction regulator and arranged to buck or boost the supply voltage to the motor stator windings. Thus, in addition to controlling the motor speed, the regulator also varies the supply voltage to the motor (and hence magnetic flux and iron loss).

A similar variation of flux with speed is obtained inherently if a series connected motor is used in place of the more normal shunt connection (i.e. by the use of a motor whose speed/torque characteristic with fixed regulator position falls rapidly with load, in contrast to the shunt characteristic motor where it remains substantially constant). The series characteristic is obtained by connecting stator and rotor windings in series through the intermediary of a single induction regulator which acts both as a step-down transformer (to reconcile the differing voltage levels of stator and rotor) and as a phase shifter (to adjust the phase angle between stator and rotor voltages, and hence control the speed). The series motor is ideally suited to large fan drives, of which a typical application is the drive of the induced draught fans of a modern power station boiler which may have outputs of 1,000 hp or more.

The stator-fed motor can also be used as a self-propelled frequency convertor. The output of the equipment is taken, not as mechanical power from the shaft, but as electrical power from sliprings connected to the rotor windings. The equipment then operates as a frequency convertor converting the constant supply frequency to a variable frequency dependent on the speed. This type of equipment is extensively used in steelworks for supplying the large groups of induction motors used for the individual drives of the rolls which form conveyors linking the various mills.

## Conclusions

The success of the stator-fed variable speed ac motor is due in the first place to the fact that speed regulation is accomplished without the introduction of major losses. Additionally, the major stumbling-block to the success of earlier designs of ac commutator motors, the problem of commutation, is solved in these machines by the use of rotor windings based on a principle entirely different from those which have been used previously.

Proper attention to detailed mechanical and electrical design ensures that the equipments measure up to the exacting requirements of users, particularly with regard to maintenance and general reliability. Upon such firm foundations a variety of machines are available with special characteristics to suit the many different types of drive which have become typical of modern engineering practice.

# Foundation Design for Modern Buildings

**Modern foundation engineering began with the inception of soil mechanics, taking into account the mechanical properties of the soil at the site. In the future, the building and the ground may be designed as one structure.**

*By Thomas Whitaker, M.Sc., A.M.I.C.E.*

*Building Research Station*

BEFORE the 19th century foundations were not designed; the surface soil was removed and the foundation started when reasonably hard ground was reached. If this was not possible within a convenient depth, or if water hindered the digging, piles were driven, cross timbers laid and the building erected on them. Since the majority of buildings were of only one or two storeys in height they could be carried by a dried surface crust or a gravel river terrace. The collapse of a more ambitious structure through failure of its foundations must have been a common occurrence, and of those that remain many have suffered considerable settlement. Towards the end of the century it became a practice to assign an allowable load per unit area to each type of soil based on general experience. When a new building was proposed a trial pit would be dug, the soil at the proposed foundation level identified, and the size of the foundation calculated. Sometimes a small area would be test loaded to " prove " the ground.

From the beginning of the present century, larger and still larger buildings have been demanded in order to place offices, factories and hotels in or near the established community on sites where land values are high, and often to satisfy the urge to outstrip rival enterprizes with a towering edifice. Many large buildings with foundations designed in the best " traditional" manner settled seriously in the course of time, and the problems raised by the skyscraper and similar heavy buildings on alluvial soil clearly required a different approach to their solution. This was provided by the development of the science of soil mechanics.

## Soil Mechanics and Design

Modern building, or more correctly modern foundation engineering, may be said to have begun when foundations were designed to suit the measured mechanical properties of the soil actually occurring on the site. The study of foundation problems is part of soil mechanics, and this relatively young science has provided the foundation engineer with a design discipline based on the principles of applied mechanics. The major difference between structural and soil mechanics is that, whereas the designer of steelwork or reinforced concrete can choose the material he uses, the foundation engineer has to deal with whatever nature has provided.

A grain elevator near Winnipeg, completed in 1913, tilted rapidly to an angle of 27° when filled for the first time. The raft foundation was 77 ft wide, 195 ft long and 12 ft deep, and at failure the load on the soil was 2·1 tons per sq. ft. It was local opinion that 3 to 4 tons per sq. ft could be taken as the bearing capacity of the clay, and loading tests on the soil had been made. Borings showed the strata to consist of firm clay with a stiff surface crust overlying bedrock at 50 ft depth. Failure occurred due to the overstressing of the clay at depth.[1] It may be shown that the lines of equal vertical stress (isobars) in the soil beneath a foundation take the form of a bulb, as shown in Fig. 1a. The bulbs from small adjacent foundations merge to form a large bulb. If piles are used, their effect is to shift the bulb of pressure lower into the ground as in Fig. 1b. This simple concept, showing that the ground is stressed to an important degree to a depth dependent on the width of the building, forms the starting point of modern foundation design.

Paper presented to the Engineering Section of the British Association, at Norwich, August, 1961.

A foundation has to be so designed that the building does not plunge into the ground due to failure of the soil, and of the various formulae which have been derived for the ultimate load capacity of a foundation probably the best known and most generally used is that due to Terzaghi.[2] This shows the bearing capacity to be dependent upon the cohesion, angle of internal friction and the density of the soil, and upon the width and the depth of the loaded area. The soil properties are found by tests on soil samples extracted from the site in as undisturbed a condition as possible, or by penetrometer tests *in situ*. In the case of deep foundations, some of the load is carried by tangential skin friction at the surface of the shaft as well as by the forces normal to its base. So far, no complete analytical solution for the deep foundation has been obtained, and the bearing capacity is usually found by calculating the separate contributions of the base and the shaft.

Another important contribution of soil mechanics has been to show the role played by the water in the pores of the soil. Except for arid zones, and in special circumstances, " ground water " is found in alluvial soils to within a short distance of the surface, and most of the soil within the bulb of pressure of a large building would be saturated.

Saturated soil may be regarded as a two-component system, consisting of an elastic skeleton formed by the mineral particles in contact with one another, with a relatively incompressible fluid filling the interstices. At any depth the weight of soil above is carried jointly by the inter-particle pressures and the pressure in the water. If a load is placed on a portion of the surface the immediate effect is to increase the pressure in the pore water, which then begins to flow from beneath the load to the surrounding

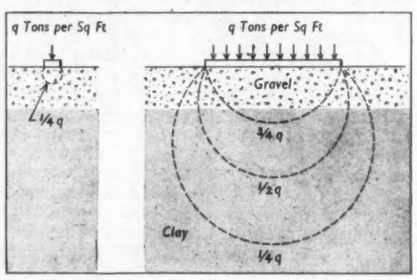



*Fig. 1a Lines of equal vertical stress (isobars) forming " bulbs of pressure " beneath small and large raft foundations.*

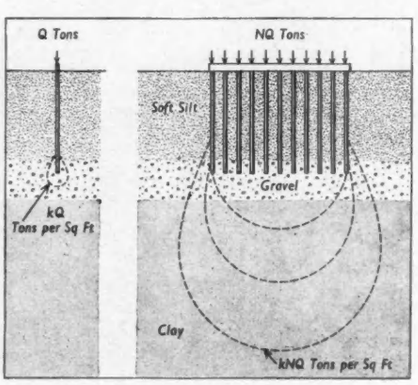



*Fig. 1b The bulbs of pressure beneath a single pile and a pile group.*

zones of lower pressure. This allows load to be transferred to the mineral skeleton, and as the particles are pressed more closely together, the loaded surface settles. The rate of settlement depends upon the rate of water movement, i.e. on the permeability of the soil. In gravel or coarse sand, the outflow of water would be so rapid that the excess pore water pressure would quickly dissipate. With silt the process would be slower, while the settlement of a building on clay or peat would go on for many years.

Mexico City is built on alluvial soil of great depth and has a long history of troublesome settlement both of the ground surface, and of buildings relative to the ground. When the monumental Palace of Fine Arts was commenced in 1904 it was designed to have great structural strength; the foundation mat alone weighed 46,000 tons. Settlement and cracking of the building occurred continuously during the 30 year construction period, and the building is now 10 ft lower than its surroundings. The cause is partly the removal of ground water by pumping, and partly the heavy building load.

In any building it is necessary to keep the total settlement and the differential settlement between adjacent parts of the structure within acceptable limits, and on all but the strong incompressible soils this requirement generally determines the type of foundation design. With alluvial soils the problem becomes that of transferring the building load to the soil at such a depth that the compression of the strata below this level will not cause a settlement greater than can be tolerated. The settlement caused by consolidation of beds of silt or clay can be determined to a reasonable degree of accuracy by making consolidation tests on undisturbed samples of soil. By taking into account the increase in pressure at different depths caused on the beds of soil within the bulb of pressure, the change in thickness of each bed may be calculated; the total change of thickness being the settlement. The calculation of the rate of settlement is analogous to other diffusion problems. The solution for the case of drainage in one direction, derived by Terzaghi, is the approximation normally used in design, and gives an answer of the correct order for the settlement to be expected.

The raising or lowering of the ground water level in a soil has been known to cause settlement of buildings. Inundating a dry sand with water causes a reduction of the inter-particle pressure due to buoyancy effects on the particles and a reduction in bearing capacity which may be sufficient to cause settlement. Lowering the water table in clays either by drainage or by evaporation will cause consolidation and settlement; and, conversely, wetting will cause swelling of the clay and lifting of the building unless the building load exceeds the swelling pressure.

One might consider it to be self-evident that any foundation should be designed so that its construction is a possibility, but the history of foundation engineering shows that major difficulties often arise in the course of excavation and construction.[3] Very often the design of a foundation and the manner in which the work may be done is governed by the need to cause as little disturbance as possible to adjacent buildings. The presence of a new load on the ground will of itself cause some settlement of the surrounding area, but other causes of settlement are by soil running through the timbering used to support the sides of the excavation, or by deflection of the planking and strutting due to the earth pressure.

Excavation in waterlogged sand, often called " running " sand, has lost much of its terror for

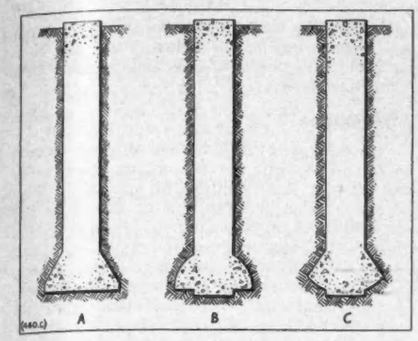



*Fig. 2 A represents the section of a typical hand-dug deep pier with an enlarged base. Machine bored and under-reamed piers may take the form of A, B or C, depending on the way the under-reaming cutters operate.*

the civil engineering contractor with the development of the art of ground water lowering, and improved knowledge of the mechanism of seepage, but to use ground water lowering in a built-up area may cause settlement of adjacent buildings. If the foundations of an adjacent building are at a higher level than the base of the excavation they may need to be underpinned. In sand or gravel the injection of grouts containing Portland cement and clay, or a combination of calcium chloride and sodium silicate to form a binder of calcium silicate, may be used to strengthen the soil. Occasionally, freezing of the ground water has been used to give temporary support or to hold back running sand.

## Types of Building Foundation

If a good bearing stratum is present near the ground surface, and tests on the soil beneath show that settlement will be within acceptable limits, then a " designed " foundation may not differ greatly from the traditional pattern. Very often, however, a heavy building on alluvial ground will require a deep foundation, which may be provided by piers or by piling. In some American cities, such as Chicago, where " hard pan " or rock is covered by about 100 ft of clay, it was the practice to excavate shafts by hand, and often the bases would be undercut to form " bells " of large bearing areas, as in Fig. 2. Drilling rigs were later developed to bore the shafts and undercut the bases. The holes, when filled with concrete, formed piers capable of carrying high loads on a suitable stratum.

Large bored foundations have been introduced into Britain within the last decade, particularly in London, where a bored pier may be formed in the clay by a large drilling machine in a few hours. A typical drilling rig is shown in Fig. 3. The foundation for a 32-storey building in London formed of a group of bored cylinders is shown in Fig. 4. Soil which is too strong for drilling, and yet needs to be removed, can be excavated by a heavy hammer grab. The deep cylinder or pier type of foundation fits in very well with modern framed-building design, in which the loads are concentrated at the points where the columns occur and may amount to 1,000 tons or more.

Timber piles have been used since ancient times to transfer loads through soft ground to a stronger stratum. Present day driven piles are largely reinforced concrete or steel, and bored piles are formed of concrete cast *in situ*. Recognition that even a very weak soil can give adequate support against buckling to a pile with its point bearing on rock has encouraged the use of very slender steel piles. For example, piles formed of steel rails 4·7 in wide and 4·5 in high over 100 ft long have been used to carry a working load of 70 tons.[4] Where end-bearing piles cannot be founded on a resistant stratum, piles which transmit their load to the soil principally by skin friction at the surface of the pile shaft may be used in suitable cohesive soil. Heavy buildings have been built on friction piles in many parts of the world, for example in Shanghai, where recent alluvial material extends to an unknown depth, and in London where the clay is of early Tertiary age and is comparatively stiff.

Piles are generally installed in groups to provide sufficient bearing capacity for a heavy load, and the common practice of testing one or more piles singly for their load-bearing capacity has frequently led to incorrect assumptions concerning the bearing capacity of groups. The New Orleans Charity Hospital was founded on piles driven through soft clay to a bed of sand 44 ft below ground level. The sand bed was 6 ft thick and beneath it was soft clay more than 160 ft thick. Single piles gave satisfactory results in loading tests, but the building settled about 10 in in a few months after completion. Fig. 1b shows that the bulb of pressure of a large group of piles can stress deep strata which would be virtually unaffected by the presence of a single pile.

If neither piers nor piling are suitable in the particular circumstances, settlement may be controlled by means of a compensated or " buoyant " foundation. The principle is simple: a hole is excavated of such a size that the weight of soil removed is a substantial proportion of the weight of the construction. The practical execution of the work may not be easy and the cost may be high, though this may be offset by the value of the additional basement space provided. The release of pressure when the excavation is made causes upward heave of the strata below the hole. This is generally an elastic movement, but by recompression it represents a settlement which the foundation must undergo before the original state of stress in the subsoil is achieved. Usually this recompression occurs during construction so that the completed building is substantially stable.

A combination of " buoyancy " and piling has been used with success; the piles serve a dual purpose, firstly of reducing heave during excavation, and later of transmitting the portion of the load not carried by " buoyancy " to less compressible strata at their tips.

In a soft silt or clay the construction of a hole for a compensated or " buoyant " foundation by open excavation is seldome an easy task, and in such circumstances recourse may be made to a large caisson. The oil refinery at Grangemouth in the Firth of Forth was built on a deep bed of silt by this method.

*Fig. 3 Drilling rig for constructing large bored and under-reamed pier foundations.*

## Foundations in Special Circumstances

Although it is chiefly ability to provide satisfactory foundations for heavy building on poor ground which characterizes modern foundation engineering, there are other aspects in which a better understanding of soil behaviour offers the expectation of improved durability and performance of buildings. In areas previously considered " difficult," as for example the clay soils of southern Britain, or the " black cotton " soils of India and Africa, buildings on " traditional " foundations have cracked badly. This has been shown to be due to shrinkage and expansion of the soil with change of moisture content caused by the climate and by vegetation.[6] A vertical movement of the ground surface amounting to some inches can occur due to these causes. This can pass unnoticed unless buildings are affected, and it is only within the last two decades that measurements have been recorded and the resulting effects analyzed.

Loss of heat from boiler houses into clay causes it to dry, and the structure to settle. Similarly the loss of " cold " from cold stores will cause freezing of ground water and heaving of floors and walls. Once the cause of trouble is recognized appropriate precautions can be taken either to place the foundations deep enough to be out of the affected zone; or in the case of furnaces to provide a cooling barrier by means of ventilating ducts, and in the case of cold stores a heating barrier by using electrical heating cables.

## Research and Future Development

There are many points in the design of foundations on which theory is lacking. In the case of piling and deep foundations in which skin friction and end-bearing both play a part, more complete theories of bearing capacity and of consolidation settlement are required. The empirical approach of making full-scale tests is not usually possible because of the magnitude and cost of the experiment. Because of this, and the variability of natural soil, experiments in the laboratory have been made by many workers on models in beds of soil which are prepared under controlled conditions.

At the Building Research Station behaviour of piles in groups has been studied by means of models. We have examined, for example, the way in which the load is shared among a group of friction piles in clay by placing a small load measuring gauge at the head of each pile, as in Fig. 5. This work showed that the corner piles took most load and the centre piles least, and generally that the load carried by any pile depended on its distance from the centre of the group.

There is some controversy at the moment among engineers concerning the functioning of deep cylinder foundations with enlarged bases founded entirely in clay. The unknown features concern the proportion of the cohesive strength of the clay which is actually mobilized as skin friction, and the way the load is shared between the shaft in skin friction and the base in direct bearing. To form some idea of the functioning of such cylinders we have made tests upon models, fitted with a load cell where the shaft joins the base, to determine the loads carried by each part.[7] Though the mechanism of failure can be found by models this gives little guide to the settlement of a full-scale foundation, and Building Research Station is at present undertaking investigations at full-scale sponsored by the Institution of Civil Engineers Committee on Piled Foundations in conjunction with contractors and consultants with the intention of producing data on this problem.

Building in areas where the support offered by the surface soil may rapidly change has received much attention in other countries. Vast regions of the world are covered by highly porous soils of the loess type. These are normally dry, and can support buildings, but when wetted there is an almost complete collapse of the soil skeleton and loss of strength. The forms of treatment have involved removal,

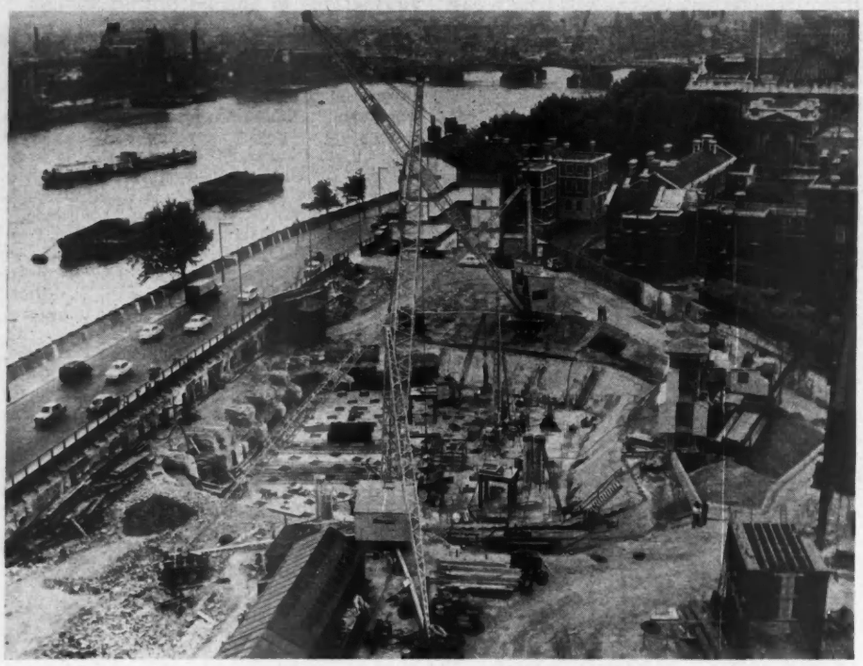


*Fig. 4 Bored pier foundations for a 32-storey building in London. Bored or pier type foundations are well suited to modern framed buildings where loads are concentrated below columns.*

saturation and compaction by a temporary load prior to building, and piling.

In parts of Alaska, Canada and USSR the ground is permanently frozen to considerable depths. The surface thaws in summer, or where heated by buildings, the softened ground being very compressible and a source of trouble if buildings are not adapted to the conditions. Small buildings may be erected on piles anchored in the frozen soil below the zone of climatic change. Large building construction involves controlling the downward heat loss, so that the rate of thawing is not great enough to damage the building by causing rapid settlement.

The prevention of damage to buildings by mining subsidence is a subject frequently raised in Britain. Observation shows that the subsidence movement has the form of a half-wave slowly passing across the ground surface as the underground workings advance. Monolithic construction strong enough to ride the wave as a ship would be uneconomic, and the opposite approach, in which the building is completely flexible and can conform to the positions taken by the ground surface, is being tried. Single and multi-storey school buildings following this principle have been constructed experimentally in Nottinghamshire.

The need for car parks in city centres is being met in many countries by underground structures set in open spaces. The more ambitious proposals envisage the excavation of large areas to a depth of 70 ft or so to accommodate multi-storey construction, while, to preserve the open space, the "roof" would be near the original ground level. In such a case the total weight of the structure, even when in use, would be only a fraction of the weight of the soil excavated, so that the construction would cause unloading of the ground beneath it. With a clay soil, the foundation engineer has the problem of estimating not only the elastic heave and the amount of recompression of the bottom, but also the slow additional movement due to the swelling of the clay when permanently relieved of some of its original stress.

Since a high building used as an hotel or for offices creates its own car parking problem, some architectural planners have proposed underground car parks around their tower blocks. Where clay is encountered, this juxtaposition of zones of stress release and stress gain in the soil presents new problems for the foundation engineer, particularly if the tower block is eccentrically placed. Some research is in hand on the expansion of clay following stress release, but there needs to be considerably more research, particularly on the theoretical mechanics of the problem, before the engineer can reduce the number of assumptions he has to make when evolving a practical design for a structure of this sort.

In considering a building to be erected on a bed of soil the soil mechanics engineer is very conscious that the two form one mechanical system, and the way the stresses are distributed in both building and soil is determined by the manner in which they "give" under load.[8] The existence of composite action is recognized by structural engineers, who are, for example, beginning to assess the effect of composite action of structural frames and their cladding material. Acceptance of the idea that building and foundation cannot be divorced from each other in design represents the first step forward, but research has a long way to go before there can be a complete integration of soil and structure in a composite design.

## Conclusions

The theories of soil mechanics have gone a long way to help the foundation engineer by indicating a right method of approach to his problem. The greatest change has been the substitution of the measurement of soil properties for the art of identification and choice of loading by rule of thumb. Soil is a very variable material, however, and genuine practical experience of local conditions can often fill in the gaps which theory cannot bridge at the present time. There is still the tendency today for an architect to choose the sort of structure to be built irrespective of the soil conditions, and this has provided the main challenge in the design and construction of foundations for modern buildings. In the long run, however, this method of approach cannot prevail, and for the building of the future design will need to be fully integrated, paying respect to the composite action of structure and soil to create a form of building in which both are used to their best advantage.

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In the article "Mechanical Aids on Site" (ENGNG., 9 June '61, p. 794) it was implied that Mr. J. F. Eden was the head of the Mechanization Division of the Building Research Station, Watford. Mr. Eden is in fact the head of a section within the division, which is in the charge of Mr. K. G. H. Fryer, O.B.E., M.I.Mech.E.

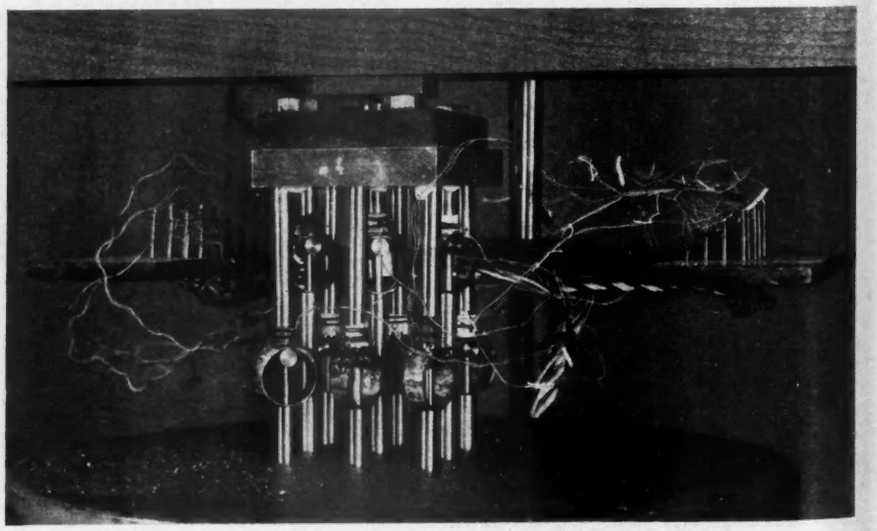
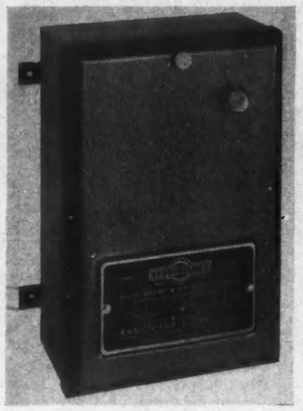


*Fig. 5 A group of ¼ in diameter model piles in clay as used in experiments at the Building Research Station. Each pile is fitted with a small load gauge.*

## PHOTO-ELECTRIC RELAY

### Adaptable



DESIGNATED type QT60, this transistorized photo-electric relay is intended for operating industrial controls.

Claimed to offer a higher standard of adaptability and reliability than previously attained, it is also said to be able to solve an increasing number of control problems in industry. The unit measures 7⅛ in high, 5 in wide, and 2¾ in deep. The example illustrated is made from 20 SWG steel but a cast-alloy housing is also available. The quick-release plug-in chassis facilitates maintenance; swinging down on hinges it exposes all components and provides space for cable slack.

The minimum duration of light interruption required to operate the relay is 0·025 sec. Maximum rate of operation is 5 impulses per sec. The projector lamp is 6 V 3 W and the total power consumption 7 W. The relay DPDT contacts are rated at 800 W.

Many standard projector and receiver units are available for use in conjunction with the relay. These can be supplied with ball and socket fixing mounts. The small size of these units permits the light beam to be located in positions which it is said would previously have been regarded as impossible. *Radiovisor Parent Limited, Stanhope Works, High Path, London SW19.*

## WELDING-FLUX SEPARATOR

### Magnetic

THIS magnetic separator will collect mill-scale particles from reclaimed unused flux during submerged-arc welding operations.

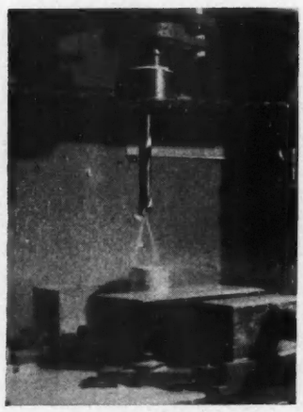
Magnetic operation is a convenient method of removing the particles which are frequently picked up when welding. These particles can cause porosity if not removed and among the troubles which may be traced back to them is holding-up of the wire as it passes through in-feeding devices. The top portion of the separator is a cylindrical hopper 10 in in diameter and 3 in deep. Slots in the bottom permit granular flux to flow through the hopper. Immediately under the slots are solid cylindrical magnets which resemble rollers and are free to revolve as the flux flows over them. A hinged cover, with slots similar to those in the hopper, fits under the magnets. It retards flux flow to a suitable rate for the proper removal of particles.

Flux flows into the hopper and any magnetic material in it is separated before it passes out. When the magnets have picked up particles to their full capacity the flow through the separator ceases and is restored by cleaning. This is easily and quickly accomplished by openjng the hinged cover and brushing the magnets.

The separator is said o be suitable for use in conjunction with any mild-steel submerged-arc flux and with some hard-surfacing fluxes. The high rate of flow enables large quantities of flux to be handled. *Armco Limited, 76 Grosvenor Street, London W1.*

## TIPPED TWIST DRILL

### Feeds Coolant



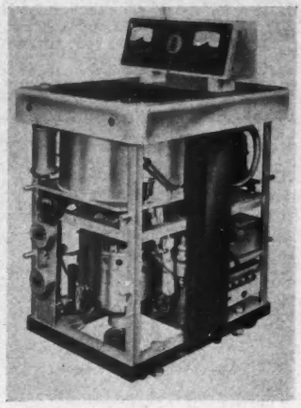
TO OVERCOME difficulties experienced when drilling high-tensile and tough materials the cold point drill has been produced.

Provided with a tungsten carbide tip, the drill has a hollow stem which allows coolant to flow through two passages at the tip to the cutting edges. It is claimed that in addition to enabling hard materials to be drilled at a faster rate than previously, blunting and jamming by chips is prevented, holes are held to size with a smooth finish, and production is speeded up. Work hardening is also said to be eliminated.

Deviations from standard practice are the use of negative rake, the employment of a point having—for most work—an included angle of 120° (nominal), and a tip circle with a slight back taper. Cutting speed must be above 200 ft per minute, except for a few materials. It is reported that the higher the cutting speed the better the finish and penetration rate. Feeds must be low for hard materials and best results are obtained when these are of the order of 0·001 in per revolution, again dependent on material. Coolant must be water-soluble oil delivered at a line pressure over 85 lb per sq. in through special chucks or collets. *Coldpoint Drills Limited, 49 St. James's Street, London SW1.*

## CENTRIFUGE

### Clarifies Suspensions



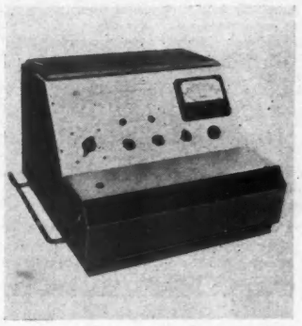
INCLUDED in the many applications of the MSE Super-speed 40 centrifuge are the clarification of biological suspensions and the concentration of polymers of high molecular weight, density gradient centrifugation and preparative work prior to analysis in an ultra centrifuge.

Incorporated devices are said to make the apparatus completely safe in operation. The entire sequence of operations, once the required settings have been made, is electronically controlled and fully automatic. Speeds from approximately 2,000 to 40,000 rpm can be obtained and held with an accuracy within ± 1 per cent, with a permissible mains voltage tolerance of 10 per cent. Speed selection is obtained by presetting of a large-scale meter. With the automatic timer in operation the running time can be preset.

To overcome loss of speed and rise of temperature due to air friction on the rotor head, the centrifuge bowl is evacuated by means of an air ballast rotary vacuum pump which is automatically brought into operation when the centrifuge is switched on. Also to prevent temperature rise the vacuum system is assisted by a hermetically-sealed refrigeration unit, controlled by a thermostatic valve. *Measuring and Scientific Equipment Limited, Spenser Street, London SW1.*

## RADIOACTIVE SCANNER

### For Chromatograms



CAPABLE of accurately measuring the distribution of radioactivity along paper-strip chromatograms, the BTL radioactive chromatogram scanner is claimed to accomplish this much more rapidly than is possible by the use of an instrument using only a single geiger counter.

Time is saved by the use of a multiple arrangement of detectors. The counting unit consists of 31 identical geiger counters, housed in a common envelope and sharing a common anode. The aluminium foil which constitutes the envelope forms a common cathode as well as serving as a window for $\beta$ particles. The counters, formed by a series of slots in a block of metal, are shielded on all sides to reduce the background counting rate. On top of the counters is mounted a selection switch which enables each probe and condenser to be connected in turn to an electrometer valve voltmeter. The potentials of the condensers are measured with this. An electrometer valve is used as the input valve to maintain a sufficiently high input impedance so that the condensers lose only a negligible amount of charge during the process of reading.

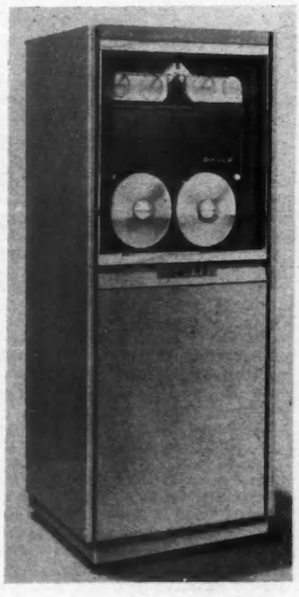
The meter is engraved to read directly in counts on four ranges, 0-1,000, 0-3,000, 0-10,000, and 0-30,000.

Overall dimensions are 23½ in wide × 21 in deep × 12½ in high. Operation is by 100-120V and 200-250V ac supply only.

*Baird and Tatlock (London) Limited, Freshwater Road, Chadwell Heath, Essex.*

## MAGNETIC-TAPE TRANSPORT

### For Computers



THE type 4000 computer magnetic-tape transport is for operation with high-speed computers now coming into service.

Features are said to be absence of computer programme restrictions, quietness in operation, the provision of automatic loading and unloading routines, simplicity in design and operation, and absence of maintenance adjustments. Two versions accommodate 1 in and ½ in magnetic tape. Dual write/read heads are available at 0·39 in spacing in order to provide for immediate check-back of recorded information. Standard data rates are 45,000, 90,000, and 180,000 characters per second.

Pneumatic drive of the tape permits rapid but smooth accelerations and decelerations to be achieved while maintaining correct registration of the tape with the head. The unit employs large-capacity bins as tape reservoirs giving smooth acceleration of the tape reel. *Decca Radar Limited, Albert Embankment, London SE1.*

# EUROPEAN MACHINE-TOOL EXHIBITION

## Brussels, 3-12 September

THE seventh exhibition organized by the European Committee for Co-operation of the Machine-Tool Industries will be opened on 3 September, at the Palais du Centenaire in Brussels. Some 4,000 machines are to be exhibited by 762 manufacturers, including 65 British.

Some of the machine tools exhibited are described and illustrated on this page. Also displayed are small tools, machine-tool accessories, measuring instruments and apparatus, equipment for control and checking, testing machines, welding equipment, heat-treatment equipment and machines for moulding metals and plastics.

## HOB SHARPENER

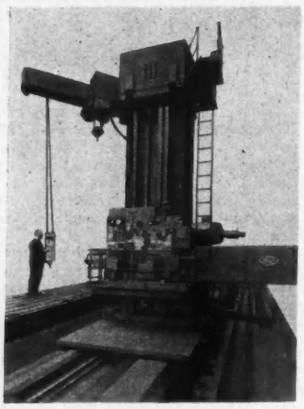
THE No. 6 hob sharpener will accommodate hobs up to 6 in diameter and 12 in long.

It is claimed that the machine is unique in that, by utilizing an appropriate gauge, the capacity may be used to sharpen, say, three 4 in hobs in one mounting. The machine is reported to be extremely simple to set and operate. Unit construction assists maintenance. Table speed up to 25 ft per minute is variable by hydraulic means. Any stroke up to a maximum of 17 in is available in any desired section.

Hobs from 4 to 36 gashes can be sharpened, the setting for lead of gash being obtained with a sine-bar device built into the machine. Setting is calibrated to one minute. Hydraulic indexing is provided and an interlock prevents table movement until indexing is complete. A choice of hand and automatic feeds is given. In both cases it is possible to grind in either direction. *David Brown Industries Limited, Britannia Works, Sherborne Street, Manchester 3.*

## MILLING AND BORING MACHINE

### Wide Speed Range



THIS ram-type machine, with a 6 in spindle, has been designed for maximum versatility of operation on large workpieces at one setting of the component.

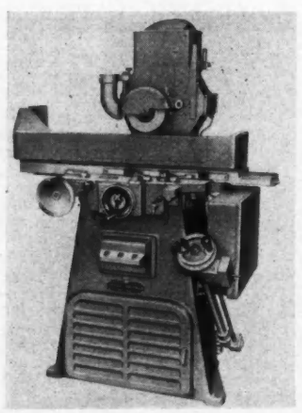
The machine is of sturdy proportions and rigidity is maintained even, it is reported, when milling at full power with the ram fully extended.

The spindle, carried on the rectangular-section ram, is mounted on ball and roller bearings, and driven by a variable-speed motor of either 30 or 50 hp. Mechanical changes give an infinitely-variable range of 1¼ to 500 rpm. Various attachments may be bolted to the end face of the ram and driven either by the milling sleeve or the spindle. In certain instances, such as with the drilling and tapping attachment, they are driven from the auxiliary lay shaft. Milling feeds to the slide and column are obtained by separate motors and gearboxes.

The machine has a vertical travel of 8 ft 0 in and horizontal traverse of 20 ft; these capacities can be altered to suit requirements. When the standard traverse is used the width of the bed is 6 ft 0 in and this can be applied to a vertical travel of 10 ft 0 in; above this size it is necessary to increase the bed width. *Asquith Machine Tool Corporation Limited, King Edward House, New Street, Birmingham 2.*

## SURFACE GRINDER

### Hydraulically-Operated Feeds



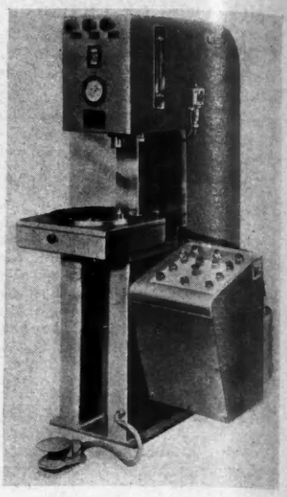
RECENTLY introduced, the Model 1540 surface grinder has been developed from the Model 540. It has greater stability and incorporates many features intended to ensure a long and accurate operational life.

Simplicity of design, ease of operation, and automatic lubrication of all moving parts are characteristics of the machine. The capacity is 6 in by 18 in. The table is arranged for both hydraulic and hand operation and has a maximum longitudinal traverse of 19½ in. Under hydraulic power the table speed is infinitely variable from 5 to 72 ft per minute including reversals. The hand controls and power traverse are interlocked to prevent the hand traverse being engaged when the table is traversing under power. Maximum cross traverse of the table is 6¾ in, both hand and automatic operation are provided. The feed range when hydraulically operated is variable from 0·007 in to 0·154 in per stroke. Application of the desired feed is instantaneously and equally applied at each end of the table stroke.

The maximum height between the table top and wheel centre is 14½ in. The wheelhead has a power-operated vertical traverse of 11 in. Micrometer vertical adjustment is in increments of 0·00005 in. *Jones and Shipman Limited, Marborough Road South, Leicester.*

## HIGH-SPEED HYDRAULIC PRESS

### Double-acting



NOW on the market, the RG high-speed hydraulic 5 ton press illustrated has been developed to speed-up press operations.

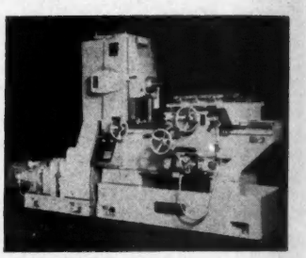
The accumulator system provided is claimed to give rapid ram advance with instantaneous speed reduction and the application of full pressure immediately the load is applied. The double-acting cylinder and ram provide positive 2 ton power return. The 5 ton model can be supplied for bench mounting or with pedestal for floor mounting. If required it is also available for foot operation.

Working pressure and slow advance of the ram for setting are controlled by a conveniently-placed regulator; a pressure gauge and isolating valve are provided. Rotation of the ram is prevented by a spring-loaded plunger. The stroke is readily adjustable. The high ram speeds of 1,000 ft per minute for approach, 35 ft per minute for pressing, and 650 ft per minute for return, contribute to the rapid operation of the unit.

Maximum ram stroke is 4 in, throat depth 7 in, and height (table to ram) 12in. The model displayed, is a 10 ton one. *Dowding and Doll Limited, 346 Kensington High Street, London W14.*

## TOOL-ROOM BORING MACHINE

### Spindle Model



DEVELOPED from the S Type machines, this optimetric high-speed horizontal toolroom boring machine is intended to deal with components, up to about 1 ft cube, which require holes with a high degree of finish and accuracy between centres.

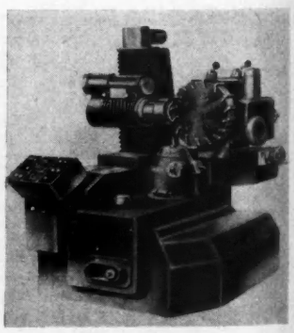
The vertical column is arranged to take a central thrust. Two square-sectioned guides at the front and two at the back ensure rigidity and stability. The compound table, on which is mounted an 18 in square revolving table, has infinitely-variable power-feed. This comprises a ¼ hp motor driving a Kopp unit giving feeds from $\frac{1}{16}$ in to 4 in per minute to either the longitudinal or transverse motions. This stepless feed enables the machine to be used for fine-boring operations by combining a low feed rate with a high spindle speed. The high feed rate in the transverse direction allows light milling operations to be carried out at the most efficient rate.

The spindle is mounted on ball and roller bearings. To reduce transmitted vibrations to a minimum the main driving two-speed gearbox is mounted on an independent baseplate alongside the machine. An infinitely-variable speed range is available from 50 to 2,000 rpm.

An optical system is provided for the vertical adjustment of the spindle slide and transverse movement of the tables. It employs a finely-divided scale engraved on glass and projected on to a large screen with a vernier giving direct readings to 0·001 in, limit of error being ±0·00025 in. The maximum distance from the spindle nose to the main table is 12 in. *H. W. Kearns and Company Limited, Broadheath, Nr. Manchester.*

## CUTTER-GRINDING MACHINE

### For Milling Cutters



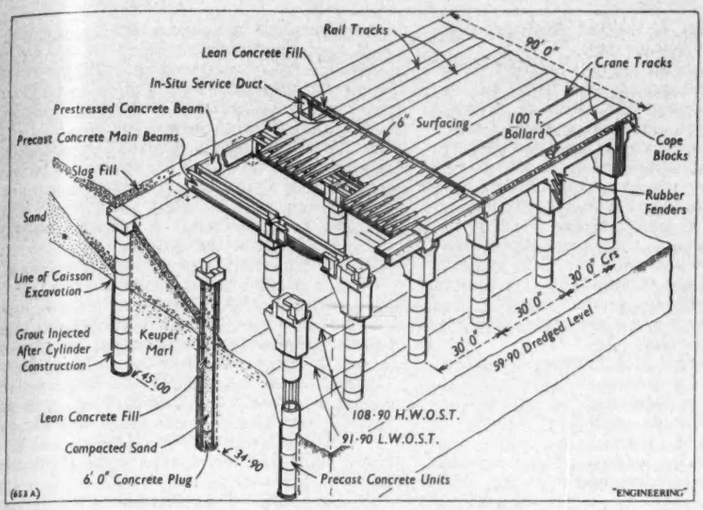
DESIGNED for grinding the blades of inserted-blade milling cutters the FCG30 machine is able to handle both carbide and high-speed steel tools.

An abrasive grinding wheel and a diamond wheel are mounted on individual spindles. The diamond wheel is brought into use by swivelling the grinding-wheel unit through 180°. The main cutting edge of the cutters can be joined to the dish edge by one or more chamfers or by a radius. In the latter case the whole contour of the blade, including the radius, can be ground in a single operation. The machine can also be used to carry out a cylindrical-grinding operation to rough grind the blades by a simple rotary movement.

Automatic cycles for three different methods are incorporated and are selected by a switch. In each method the pre-set cycle of grinding repeats automatically until all blades in the cutter have been ground. No dividing plates are necessary since the blades themselves determine the required position by indexing against a flexible rest.

The grinding spindle can be power traversed in a vertical direction.

Cutter diameter is from 3 to 30 in. The diameter of the cup grinding wheel is 6 in and its speed 2,800 rpm. The diamond wheel has a diameter of 5 in and runs at 4,400 rpm. Maximum stroke of the grinding slide is 5 in. The cutter head has a maximum swing of 100°. Maximum radius at the corner of the blade is 1 in. *Kendall and Gent Limited, Victoria Works, Manchester 18.*



*Details and appearance of the quay construction. The precast units are limited in weight to 15 tons.*

# Prestressed Quay Built "In the Wet"

**A five berth quay, 3,250 ft long, is being built of precast prestressed concrete units. The piers have been sunk through the water into disturbed marl on the banks of the River Tees.**

In 1946, to provide additional deep water berthing facilities, the Tees Conservancy Commissioners obtained Parliamentary powers to undertake the construction and management of two additional tanker berths and five new general cargo berths. The two tanker berths were built first and were completed in 1950.

In 1954 Sir William Halcrow and Partners were appointed to design five tidal berths having an initial depth of 32 ft and an ultimate depth of 37 ft alongside at low water spring tides. These berths are now being constructed on reclaimed land on the south bank of the Tees in a basin 3,250 ft long and 400 ft wide laid out at right-angles to the river between Grangetown and Redcar.

## DESIGN

A site investigation contract was let to Le Grande Sutcliffe and Gell Limited for boring and sampling of the ground and to carry out pumping tests to establish the feasibility of constructing the berths in the dry. In the course of the investigation, however, two facts emerged which led to the decision to construct the berths by wet methods. Firstly it was found that the slag stone embankments which enclosed the site were extremely porous and would be costly to seal, and secondly it was found that suitable foundation material for gravity type structures did not generally exist above level 30 ft Works Datum (the finished top level of the quay is around 115 ft WD). Various alternative designs were prepared for a quay structure 60 ft high measured from cope to bed level and very quickly it became obvious that an open type structure was the most economic. This conclusion was confirmed by local experience of the free standing nature of dredged faces in the lower marl.

Detailed designs were prepared in 1956 but, because of the Government's financial policy, it was decided to defer the construction of the berths until more suitable conditions prevailed. However, reclamation of the area between the quay and the Tees Dock Road proceeded by pumping sand, dredged from the river in the course of maintenance operations, into bunds. In all, 2,100,000 cu. yd of sand, boulder clay and disturbed keuper marl were dredged and pumped ashore for a reclamation works.

Instructions to invite tenders were given late in 1958 and during the preparation of the tender documents it was realized that the original design of the deck structure would no longer necessarily be the most economic. The original design had included large precast reinforced concrete deck units weighing up to 80 tons each but in the meantime the rapid development of prestressed concrete suggested that further economies might be possible. A. J. and J. D. Harris were invited to prepare an alternative design for a prestressed concrete deck structure with elements weighing not more than 15 tons each. Both designs were included in the tender document and the successful contractor, the Demolition and Construction Company Limited, priced the prestressed concrete scheme cheaper than the alternative in reinforced concrete. Instructions to commence work were given on 1 August, 1959.

**Structure.**—The present work consists of an open type quay at right-angles to the Tees along the western side of the basin. The quay will be 3,220 ft long and 90 ft wide supported on concrete cylinders with a roundhead at the river end. An embankment of slag stone lies beneath and behind the quay structure; the form of the work is illustrated above.

For transport by road of heavy loads to and from the ships the deck has been designed to permit the free movement of 200 ton low loaders and 64 ton capacity mobile cranes anywhere on the quay.

The substructure consists of 330 concrete cylinders arranged in bents of three, with the bents at 30 ft centres and the three cylinders in each bent 30 ft and 38 ft apart respectively. The length of the cylinders varies from 43 ft to 67 ft depending on the nature and level of the ground beneath the quay.

The cylinders comprise precast concrete hollow sections 6 ft long with an external diameter of 6 ft 3 in and an internal diameter of 4 ft 9 in, stressed together after erection by Macalloy high tensile steel bars. The cylinders are sealed at the toe with colloidal concrete and filled with weak concrete and sand; the rear and centre cylinders are finished with an *in situ* reinforced concrete capping but the front cylinders are topped with large concrete fender blocks. The Macalloy bars in the front cylinders are extended through the fender blocks by couplers. Stressing is then carried out from the tops of the fender blocks.

The substructure of the roundhead is similarly constructed but, in this case, the cylinders are in bents of four.

The superstructure consists of pairs of main transverse prestressed concrete I beams spanning between the cylinders in each bent and supporting precast prestressed deck units. Each of the transverse beams is cast in two sections 30 ft and 38 ft long, 6 ft deep and 1 ft 8 in wide. When in position the two sections are stressed together to provide continuity over the central support and to the fender block to obtain portal frame action under berthing loads. The spaces between the beam units over the central support and between the end of the beam and the fender block are filled with *in situ* concrete.

The decking units weigh 12 tons each and they are carried on the transverse beams and are stressed together transversely; longitudinal continuity of the deck is obtained by dovetailing of the deck units over the transverse beams. In addition, longitudinal beams span between the front cylinders and between the rear cylinders. The transverse cables in the deck units pass through the front line of these beams to tie them back into the deck structure.

The deck of the quay is completed by a 6 in layer of *in situ* reinforced concrete on 1 ft 6 in of lean concrete. The berthing face is also finished with *in situ* reinforced concrete 9 in thick. Expansion joints are provided at 600 ft intervals.

A service gallery, 7 ft 1½ in by 4 ft 1½ in, is formed at the rear of the quay by utilizing the longitudinal beam as one wall and by constructing the remainder of *in situ* concrete. Transverse ducts and service pits are provided in the *in situ* filling of the quay.

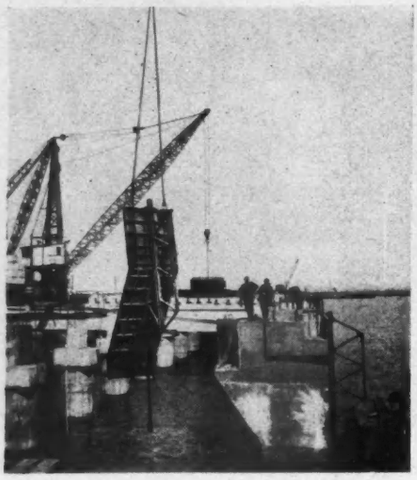
The superstructure of the roundhead is of similar construction to the main quay but is reinforced by additional lateral beams.

Fenders and mooring attachments are provided at each fender block, the former consisting either of Greenheart timber or 15 in diameter Goodyear hollow rubber fenders.

## FOUNDATION TESTING

The pre-contract site investigation had indicated that the soil beneath the quay consisted of massive rock, like Keuper marl, overlain successively by 50 ft of disturbed marl, 10 ft of boulder clay and between 5 and 20 ft of fine sand. The disturbed marl became much harder with depth, though recurrent bands of soft continued until the massive marl was reached. Great difficulties were experienced in satisfactorily sampling the disturbed marl and, despite careful testing, considerable doubt remained on the validity of the foundation calculations.

The Cementation Company Limited were selected to undertake an additional investigation in conjunction with main contractors. The work included boring, sampling and testing, *in situ* plate bearing tests and a 1,000 ton test load applied to a completed cylinder. At this stage of the investigation the conclusion formed was that no satisfactory foundation, using piles



*Striking the steel shutter from a cast fender block. The shutter can be sealed so that concrete can be placed at all states of the tide.*

relying on end bearing alone, could be formed above the level of the marl rock, which was generally 15 ft below contract founding level.

The trial cylinder, provided with longitudinal cables capable of exerting 1,000 tons axial load, was constructed on a layer of soft material thought likely to cause unacceptable settlement. The cables were grouted into the rock and the load from eight hydraulic jacks applied. Settlement was recorded for various loads and from the results obtained the cylindrical piers were permitted to be founded at the original level given in the contract.

## CONSTRUCTION

In view of the highly repetitive nature of the work, considerable thought was given by the contractors at the time of tendering to methods of construction. A period of three months was allowed by the Engineers to the contractors for this preliminary site work and a very satisfactory method of construction was evolved.

**Precasting Yard.**—There are 6,346 precast concrete elements to be incorporated in the work and they are being manufactured on the site. Cylinder units are cast vertically in steel moulds on bogies on a production line basis, this method comparing favourably, from an economic standpoint, with the more usual method of fixed mould positions. The concrete is supplied from the beam yard by elevator and compacted by poker vibrators. Bar ducts are formed by bright steel tubes that are withdrawn while the concrete is green. When necessary, units are matured artificially in heated sheds and are normally lifted after three days.

Beam and deck units are cast on fixed soffits, the former in steel moulds with high frequency external vibration and the latter in plywood moulds with hinged sides, using internal vibrators. Reinforcement cages are prefabricated complete with stressing tendons sheathed with Ductiflex and are placed in the moulds by a derrick. Concrete is transported to the moulds over a movable Monorail bridge which covers the whole yard area. Units are stressed when about seven days old using the CCL standard wire system modified to allow grouting through the thrust and bearing plates. Transfer of all the units to the site is by a standard gauge railway running behind the quay.

**Substructure.**—At the tender stage, an examination was made of a method of constructing the cylindrical piers in position as an alternative to the more conventional method of sinking the whole cylinder as a caisson by excavation from within the kentledge loading. There appeared to be considerable advantages and the tender accordingly was based on a full development of the second method. With very little modification, the work is being carried out on this basis, as is illustrated at the foot of this page.

To accommodate the heavy plant needed for excavation and cylinder building, a temporary staging has had to be provided of steel cylindrical piles, Bailey bridge units and prefabricated deck panels of sleepers and RSJ's. This staging is advanced as the works proceed by dismantling at the trailing end and re-assembly at the forward end. A 15 ton derrick at the trailing end dismantles the decking and extracts the piles, loading them into a motorized barge for movement to the forward end. Here re-driving of the piles and re-assembly of the decking is carried out with a crawler crane.

At the locations of each of the concrete cylinders, steel tubes of $\frac{3}{4}$ in wall thickness and 7 ft internal diameter are pitched by a derrick and sunk into the Keuper marl by a Benoto tubing machine. The tubes are extended to keep the top level above the working platform and sinking continues until a seal is obtained in the marl, usually at about 10 ft depth. At the same time, excavation is carried out within the cylinder by Benoto grabbing machines with $1\frac{1}{2}$ metre diameter hammer grabs, and the spoil is removed by dumpers. Excavation continues unlined for a further 15 to 25 ft below the tubing and from time to time the hole is enlarged from $1\frac{1}{2}$ metres to the full 2 metre diameter by a trepanning tool, also operated by the grabbing machine.

At the foundation level an *in situ* concrete plinth is constructed and on it the cylinder is built of hollow precast concrete units each 6 ft high and weighing about 6 tons. Initially, the joints were caulked with an earth dry mortar, but an improved joint of comparable strength is now produced using a sand/cement mortar with a high strength additive.

Macalloy prestressing bars and mild steel bars are lowered into ducts in the cylinder walls by derrick and nuts are fitted at the lower ends of the Macalloy bars through "windows" in the base units. Stressing follows immediately. After the grouting of the bar ducts, a Colcrete plug is formed at the bottom of the cylinder and the remaining void is filled successively with sand and weak concrete. An *in situ* concrete extension completes the cylinder to the correct level and the steel caisson is then extracted, utilizing a second tubing machine fitted with hydraulic jacks of 60 tons capacity. As the tube is withdrawn, the annular void between the concrete pier and the excavation is grouted through injection pipes from the surface.

Each cylinder, according to its location, terminates in a fender block or capping of *in situ* concrete. The fender blocks are of considerable size and are constructed using the special steel shutter illustrated on this page to allow concreting at any state of tide.

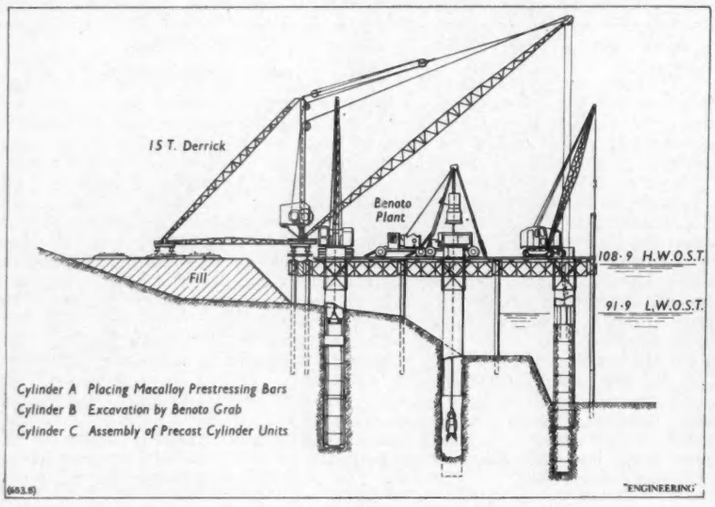
**Superstructure.**—The erection of the superstructure follows behind the substructure construction as closely as possible. The precast units arriving from the casting yard are handled into position by a derrick travelling on a gantry carried by the shore line of cylinders. Main beams are placed unstressed and the stressing tendons are winched through the two spans to be anchored at the quay face of the fender block. Attempts have been made to develop a new type of spacer of $1\frac{1}{2}$ in diameter which concentrates the cable and allows the grout to flow around it rather than through it but, pending completion of experiments, 12-wire unspacered cables have been substituted, anchored by the Freyssinet system.

Four out of seven beam cables are stressed at this stage, followed by deck slab placed to an interleaved pattern. Ductubes are drawn through the transverse ducts in the deck and inflated to allow the jointing mortar to be placed. Transverse cables are then placed and stressed, followed by the stressing of the remaining three main beam cables. Grouting of all cable ducts is carried out by hand diaphragm pump to complete the structural deck.

The remaining work comprises construction of a service gallery at the shore side of the deck, the quay facing, deck distribution slab and top deck slab incorporating crane and rail tracks, all in *in situ* reinforced concrete. The fixing of bollards, rubber fenders and rubbing strips completes the work.

*Consulting engineers: Sir Wm. Halcrow and Partners, Alliance House, Caxton Street, London SW1; A. J. and J. D. Harris, 127 Victoria Street, London SW1.*

*Principal Contractors: The Demolition and Construction Company Limited, St. James's Square, London SW1.*




*Cross-section of the temporary work and construction in progress on the cylindrical pier sub-structure.*

# Companies

## Steel and Company Show How

A RECORD profit for last year and a good start to the current year is the cheer presented by STEEL AND COMPANY LIMITED, the Sunderland firm of engineers, contractors and merchants, whose profits, recently announced, for the year ended 26 March last have stepped up to £1,276,000 from £721,000 for 1959-60.

A final dividend of 12½ per cent is to be paid on capital increased by a one-for-six rights issue, making 22½ per cent for the year against 20 per cent last time. The forecast had been a maintenance of last year's 10 per cent final. From their gross profit, the company will pay over half (£647,000) in taxation. Ordinary dividends this year, even at the increased level, will account for no more than £226,000 and on this sum, of course, individual taxation will be payable.

Mr. James Steel, the company's chairman, affirms that the improved surplus has resulted from operating their more important factories to the limit of their capacities during the past year. All the firm's traditional products and services are now operating at a profit.

Some lines, only comparatively recently introduced, with a view to providing balance and diversity to the group's activities, are still in the development stage. They should, however, play their parts very soon in building up the organization's profits. There remain a number of new products which are still to be brought into production. These manufactures will no doubt continue to cost money for a year or two, but, in due season, they will strengthen the group's position and their ultimate contribution to profits will be substantial.

Reserves possessed by the group now amount to £3,144,000.

## A Welcome to the Common Market

So far as the European Common Market is concerned, it is stated that the group's policy has long been based upon the assumption that British industry will eventually be fused with European industry.

In such an event, the group would require to make adjustments at some of their factories and they expect to feel the effects of the keenly competitive methods by which many continental manufacturers are likely to seek to establish themselves in the United Kingdom market.

For many years, however, the firm's main products have competed successfully with those of continental producers in world markets. Indeed, the group have sold their machines into continental countries in spite of high tariff barriers, currency restrictions and national prejudices. There is every confidence, therefore, that the group will gain more than they will lose, by the entry of this country into the European Common Market. This may well be so, since, mechanical handling is one of the group's main enterprises and may well gain considerably in such an event.

The future seems bright. Sales companies have obtained sufficient orders to maintain factory productivity at a high level for the greater part of the year. Production and deliveries are ahead of last year.

Mr. James Steel feels that, provided British industry is not forced into another recession, his group will be pleased with the current year's trading.

## Walker Crosweller Go Public

Having become widely recognized over the years as specialists in the design, manufacture and application of thermostatic mixing valves and allied products for water-temperature control, WALKER, CROSWELLER AND COMPANY LIMITED, Cheltenham, have decided to broaden the basis of their affairs and become a public company.

The firm have a one-class issued capital consisting of one million ordinary shares of 5*s* each and 300,000 of these were offered to the public at 8*s* 6*d* a share on 24 August. Dealings on the London Stock Exchange were expected to commence last Wednesday. The remaining 70 per cent of the firm's capital will still be owned by the Walker family.

Founded in London nearly 40 years ago by the present chairman, Mr. J. M. Walker, with the late W. W. Crosweller as manager, Walker Crosweller are essentially a family concern.

Some 40 per cent of the firm's production is exported and, during the past twelve months, their output has risen by one-fifth, mainly as a result of expansion in overseas markets. Several new products are in the design stage or are undergoing field trials.

Commenting on the change in the company's status, Mr. Richard Walker, who is a son of the chairman and the present managing director, says that, like so many family businesses, the firm have now reached the stage where they require more capital, not only for new buildings and plant but to provide a sound footing for future development. He also pointed out that, although exporting can be quite profitable in the long run, the terms for overseas credit—120 days to pay is quite common—can be a heavy drain on a firm's resources.

## A Specialist Business

Walker Crosweller instruments—the firm have an important instrument division producing a comprehensive range of factory instruments for such applications as draught, vacuum, pressure and rate-of-flow recording and metering—are marketed under the trade name "Arkon" and their thermostatic mixing valves under the name "Leonard."

Leonard valves automatically blend hot and cold water, or steam and water, to a constant predetermined temperature, for a variety of industrial, commercial, hospital and domestic purposes. There are also Leonard valves specially designed for controlling water temperatures in domestic and industrial space-heating installations.

These valves constitute the firm's most important product and account for some two-thirds of their turnover. Like the other products, Leonard valves are supplied to a large number of industries. Another of the company's products is the "Unatap" spray mixing taps for washbasins. In the accompanying illustration, valves and taps are shown undergoing final inspection at Cheltenham.

The organization exports to no fewer than 68 countries and, with the exception of Germany, where there is a subsidiary company, sales are made through agents.

Their present factory, which employs 340 persons and occupies about 34,000 sq. ft, stands on a 6½ acre site; so that there is room for expansion. One new bay of 6,000 sq. ft has been completed and plans are under consideration for the construction of a new combined office building and factory.

*Thermostatic mixing valves and spray mixing taps undergoing final inspection and cleaning at the Cheltenham works of Walker, Crosweller and Company.*

## Less Dependence on Marine Engineering

Evidence has been accumulating that there is a changing pattern of demand as between the marine-engineering and land-based power plant industries.

Referring to this change recently, Mr. O. J. Philipson, chairman of RICHARDSONS, WESTGARTH AND COMPANY LIMITED, who have been engaged on this work for many years, indicated that there must now be a greater group dependence on land work.

Bearing this aspect in mind, and in view of future prospects as forecast in the firm's annual review, a critical examination of the existing organization of the Richardsons Westgarth group had been made and certain major changes were now under way.

It had been decided to change from the relatively self-contained subsidiary-company structure of the group to centralized control. An exception would be the HUMBER GRAVING DOCK AND ENGINEERING COMPANY, in which the structure would remain as at present, in view of the nature of that company's business and its location.

## J. Samuel White to Enter Printing?

During the last few years, J. SAMUEL WHITE AND COMPANY LIMITED, the Cowes, Isle of Wight, shipbuilders, have extended their activities into metalwork and refrigeration, and it is the opinion of the company's directors that this diversification process should continue.

In pursuance of this policy, an extraordinary general meeting is being summoned at Cowes on 12 September to consider the addition of a new objects clause to the company's memorandum of association. Approval of this additional clause would enable the firm to acquire shares in other companies whether or not they carry on similar businesses.

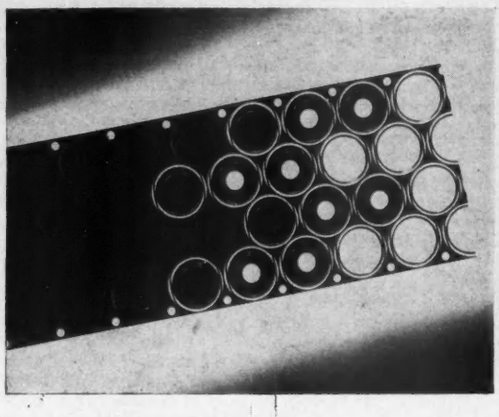
The immediate reason for this proposal is that Samuel White have the opportunity of acquiring the whole of the issued capital of J. ARTHUR DIXON LIMITED, who print and publish greeting cards and calendars. Dixon's have a leasehold factory at Newport, Isle of Wight (this is their main establishment) and a leasehold factory at Inverness.

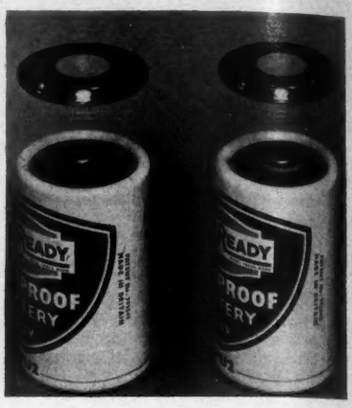
Samuel White appear to be making the acquisition on excellent terms, since the agreement which their board have negotiated provides for the purchase of the whole of the share capital, for £406,500, of a company which had a pretax profit of almost £120,000 in 1960. During the past ten years, from 1951 to 1960, Dixon's pretax profits have risen from £10,500 to £120,000. Over the last five years, it is calculated that their profits have averaged sufficient to yield around 20 per cent on the suggested purchase price.

The question seems to be whether, in the long term, postcards and calendars will provide a more staple basis for prosperity than shipbuilding, where, admittedly, there has been a decline in orders and where competition is severe.

# Off - the - Coil Prepainted Metal Strip

**Three users of a make of prepainted steel strip say the same thing: that this material can be pressed, bent or stamped without the paint coming off.**






FOR ABOUT three years, a firm in Walsall has been offering a prepainted metal strip. They are called Coated Strip Limited. Their product is delivered in coils with a maximum width of 18 in and can be covered on one or both sides with lacquer, wash-coat or paint.

Prepainted strip has often been hailed in print as the futuristic product which will make and save money both for the people who produce the strip and for those who use it. With this in mind, three customers of Coated Strip were approached with the maker's consent to find out what they felt about the product. What they said is recorded here.

It is apparent from this and from comments gleaned elsewhere that many of the fears about durability of the paint film during forming operations can be dispelled if the producer of prepainted strip is really doing a good job in preparing his strip and has his stoving formulations and conditions right. But there are much larger markets which are yet unentered.

There might be an advantage if heavy strip for metal furniture was prepainted on a continuous line. So far as is known at the moment, no company in the United Kingdom has a plant which could continuously coat, say 18 gauge steel strip in widths up to 48 in. But if the demand for the product existed, Coated Strip—as one of the potential makers—say that it would be relatively easy to put such a product on to the market.

*Coated Strip Limited, Bescot, Walsall, Staffs.*

## Miniature Car Bases

One of the uses of prepainted strip is for making bases of Dinky toys—the miniature cars produced by Meccano of Liverpool. Before the advent of prepainted strip, this firm used a glossy enamel which necessitated barrelling and degreasing before finishing off with Japan black. In their opinion, the arrival of modern prepainted strip revolutionized and simplified the processes involved.

The metal is used in such quantities that, in the words of Meccano, "if the bases were stretched end to end, close on 1,500 miles of prepainted strip would be used in a year." Some of the bases are shown below.

Meccano say that when prepainted steel strip was first used there was some doubt as to whether it would emboss satisfactorily without the paint breaking away, even after much hard wear, from the letters and figures. However, tests made beforehand, and hard usage since then, have confirmed that the prepainted steel strip is ideal for this job.

## Pressed Discs for Battery Covers

About two years ago, Ever Ready started using prepainted strip steel in small pressed parts for their batteries. The most important of these parts were circular pressed discs for use as top covers in the company's Unit Cells.

For these, Ever Ready ask for mild steel of 0·0092 in nominal thickness with a paint coating between 0·0004 and 0·0006 in thick. Sometimes they call for it to be lacquered on the reverse side, sometimes painted. Colours include blue, red and black. At the present time they are using several tons of varying widths of strip each month, supplied by Coated Strip.

At the Edmonton works of Ever Ready, a progression die press is used to press out these battery covers. Ever Ready say that the tool was developed along "conventional lines," adding that they expect to blank out 3 million covers before the tool needs touching up. Wear of the tool is kept to a minimum by precoating the strip with a light film of very weak soluble oil and this does not appear to affect the good surface finish of the strip at all.

From the illustration here you can see that there are four stages from strip to final cover. First, there is a cutting operation which leaves a suspended circular blank; second, this blank is pressed, during which the outside diameter is reduced; third, the centre is punched out; and lastly, the cover is blanked out. The company comment that in early trials they attempted to carry out all these operations in one combined tool, but this meant omitting the first stage. The stretching which then had to take place in the strip to accommodate the pressing operation was found to cause too much wear on the tool.

The die press is operated at 200 strokes a minute so that the output is 800 covers a minute from strip. Ever Ready comment that the only trouble they encounter—and this is infrequent—is when the strip comes over-thick; then the tool does not completely cut through the strip in the first operation. Otherwise, they are happy with using prepainted strip, and certainly the paint coating adheres strongly through these metalworking operations.

## Rolled Sections for Venetian Blinds

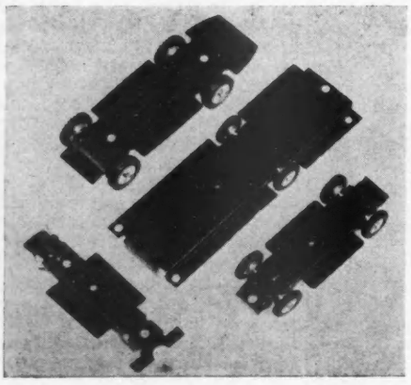
Venetian Vogue list six advantages which they have derived from changing over to prepainted strip from spraying their own rolled mild steel sections and these are listed below. This material is cold-rolled for them into channel headrail sections and semi-oval bottomrail sections. At present they are using prepainted strip, but they are looking forward to trying a plastic-coated variety to be supplied by Coated Strip which they consider will give even greater durability.

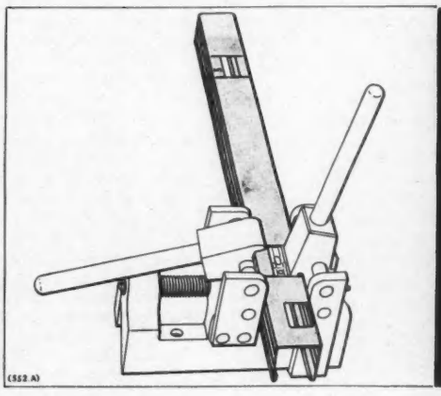
The first advantage in using prepainted strip, say Venetian Vogue, is that the material is completely coated including the edges. Previously, when paint spraying mild steel sections the inside of the bent-over lips was not covered and rusting occurred easily. Also, it was found that paint clogging would easily take place.

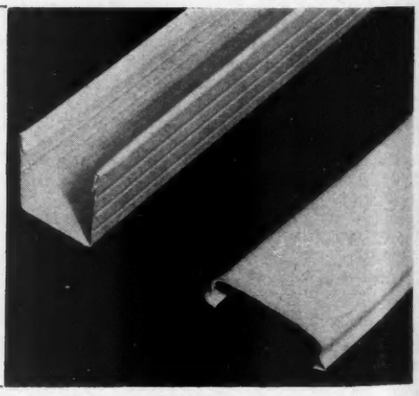
The roller-coated surface shows no orange peel or running away to edges, they add, and is compatible with the roller-coated surface of the aluminium slats. The strip for the rolled section is phosphated prior to roller-coating and the paint covering is thinner than the previously sprayed finish, yet the section has similar resistance and durability. Since overspray is avoided, there are considerable savings in paint.

As supplied to Venetian Vogue for their Sunway blinds, the strip is roller-coated a different colour each side, thereby allowing lower stock quantities since it can be formed with either of the two colours on the outside.

Finally, this user comments that the paint surface is not disturbed by their various cutting and bending operations; the illustration here shows how the tabs in the headrail section are bent inwards to secure the tape-hole inserts.





## Structural Steel Shot-Blasted and Primed

The structural engineering and steel building company, Sanders and Forster, have installed plant for automatically shot-blasting and etch-priming all fabricated steelwork produced in their enlarged works. This finish should increase the life of the final painted finish of the steelwork by about four times, they say.

This plant is placed by the stockyard so that all material will eventually be processed before fabrication. It will handle universal beams up to 36 in wide by 12 in or 48 in wide plate. Material is fed through the plant on rollers and the maximum length of material which can go through it at the moment is 55 ft, say the company.

No extra charge will be made for steelwork supplied with this surface treatment. It will replace hand finished steel. The plant which applies the etch-primer by spray is positioned immediately after the shot-blasting installation so that there is no opportunity for rusting to occur on the freshly cleaned surface. This procedure is what is recommended by most industrial paint manufacturers for getting best protection. The surface is suitable for painting without removing the primer.

Sanders and Forster say that many of their own ideas went into the design of the shot-blasting installation. They add finally that the processing will simplify corrosion problems relating to fabricated material exposed to sea water and humidity in transit by ship.

*Sanders and Forster Limited, Warton Road, Stratford, London E15.*

## Epoxy Powder for Hot Dip Coating

Telcon Plastics are now marketing epoxy resins in powder form for hot dip coating. Particular interest is being shown, they say, in the application of the coating to rotors and stators in electric motors, the object being to dispense with the slot-liner and to enable mechanical winding to be used.

In this process an article to be coated is pre-heated and then dipped into the powder which is made to behave like a fluid by having air blown through it. The powder melts on the hot surface of the article and it hardens. Curing is needed to fully harden the coating. For the present resin, Kl0l, Telcon say that the greater part of the electrical strength is developed after 30 min at 200° C, but its chemical resistance will continue to improve up to 60 min or more at this temperature. Very much undercured coatings will crack on cooling.

After curing for 60 min at 200° C, Kl0l has been found to have the following properties: power factor at 1,000 c/s, 0·021; permittivity at 1,000 c/s, 3·56; electrical strength at 20° C, 450 volts per mil for a 13 mil (0·013 in) coating. The fluidized bed method of coating was fully described in ENGINEERING, 6 May, 1960, vol. 189, p. 604.

*Telcon Plastics Limited, Green Street Green, Orpington, Kent.*

## One-Coat Acrylic Finish

A one-coat finish for metal products has been introduced by Griffiths Brothers. It is an acrylic one and is called Armacryl. The company say that the finish is particularly suitable for domestic appliances of all kinds.

Good humidity resistance, hardness, chemical resistance, flexibility, impact strength and good adhesion are said to be obtainable on steel without a primer. A primer need only be used where a surface needs filling. The finish can be applied directly to galvanized steel where the company say the results are greatly superior to those usually obtained, but aluminium may require chemical pretreatment of the Alocrom type if the surface is highly finished.

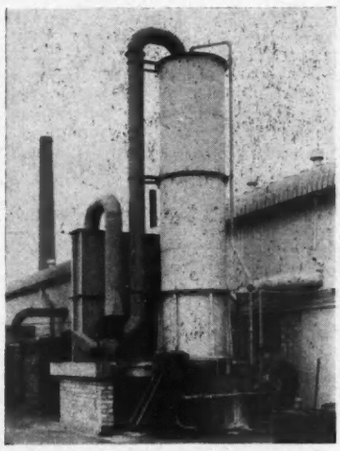
Application can be carried out by spraying or dipping, followed by stoving by convection for a minimum of 30 minutes at 300° F. Tests reported briefly by the makers indicate that the properties of this coating are very much better than those of a plasticizing alkyd-melamine type. For this comparison, single coatings were applied to bright steel, with no pretreatment apart from degreasing. Armacryl appears to resist humid conditions particularly well and may then be useful for electrical gear operating in such conditions.

*Griffiths Brothers and Company London Limited, Well Lane, Wednesfield, Staffs.*

## Strengthened Pvc for Scrubbing Tower

At the Enfield works of Johnson and Sons Smelting Works, rigid pvc sheet strengthened by a glass reinforced polyester outer skin has been specified for construction of the scrubbing tower and pipework.

The scrubbing equipment can handle up to



2,000 cu. ft of acidic gases a minute, say Bakelite who supplied the Vybak pvc sheet. It is immune to thermal shocks which often cause severe damage to some conventional materials. The scrubbing tower, which measures 18 ft high by 4 ft diameter, and the eliminator, measuring 8 ft 8 in by 1 ft 6 in diameter, were made by Plastic Filters of Horsham.

*Bakelite Limited, 12-18 Grosvenor Gardens, London SW1.*

## Baked-on Coating of Molybdenum Disulphide

A molybdenum disulphide " varnish " which is baked on to metal surfaces is now being sold by Rocol. Such coatings of molybdenum disulphide are widely used for lifetime dry lubrication of lightly loaded components such as ball and roller bearings, this company says. They are also useful for bearing surfaces in general, gear teeth, slides, tool faces, dies and moulds where the conditions do not permit the use of more conventional forms of lubricant.

Molytox Plus has been marketed by Rocol for several years. This is an air-drying varnish. After what the company describe as a " systematic study " in view of a tendency in the USA to base these products on thermo-setting resins which give hard bonded films, they have now formulated Molydite Plus on this basis. This is not intended to replace the former product but the makers say it will stand up to extreme conditions better than Molytox Plus. It should be used, for instance, for the most severe service on bearings, slides and gear teeth and where the surface has to resist contact with hot oils, solvents, acids, alkalis and other reactive chemicals.

The application of Molydite Plus demands more care in preparation and a drying period at 200° C must be allowed for. The resultant film is said to have withstood a pressure of over 6,000 lb per sq. in at 800 rpm for over 60 minutes when tested in a Timken machine; this is the same figure as claimed for the Molytox Plus.

*Rocol Limited, Rocol House, Swillington, Nr. Leeds.*

## Detector of Carbon Monoxide

A new detector monitor for carbon monoxide has recently been introduced in Denmark. It was invented at the State Crime Detection Laboratory at Aalborg and is distributed in the United Kingdom by Herzbi Limited.

Carbon monoxide is a particularly treacherous hazard, this company says in introducing the new detector. It cannot be seen, smelt or tasted, even when present in lethal concentrations. It occurs wherever there is combustion of organic matter. 0·3 per cent carbon monoxide in inhaled air is sufficient to cause immediate loss of consciousness and death within half an hour.

The detector consists of a small 5 cm by 5 cm plastic plate with a disc-like insert containing a sensing substance, the active constituent of which is palladium chloride suspended in a silica gel of the same yellow tint as the plate. In the presence of carbon monoxide the palladium salt is reduced and the insert turns grey or black, depending on the degree of concentration of the gas.

Tests by the Royal Swedish Defence Research Institute reported by the Government Testing Laboratory in Stockholm in 1960 have revealed the following (a direct translation of the report).

" The detector has been tested by the following concentrations of carbon monoxide: 0·01, 0·02, 0·05 and 0·10 per cent. Two plates were exposed to carbon monoxide in various concentrations until a distinct discoloration was obtained. After having been placed in pure air the plates resumed their original colour, and were re-exposed. The exposing was repeated five times with each pair of plates and in each carbon monoxide concentration. Times for faint and distinct reaction can be seen from the following table:

| Exposing | Reaction | Carbon monoxide concentration, per cent | | | |
|---|---|---|---|---|---|
| | | 0·01 | 0·02 | 0·05 | 0·10 |
| 1st | Faint<br>Distinct | 7 min<br>11 min | 2 min<br>4 min | 1 min<br>2 min | 40 sec<br>2 min |
| 2nd | Faint<br>Distinct | 5-7 min<br>8-11 min | 2-2½ min<br>4 min | 40 sec<br>2 min | 30 sec<br>2 min |
| 3rd | Faint<br>Distinct | 7 min<br>11 min | 2 min<br>4 min | 1 min<br>2 min | 30 sec<br>2 min |
| 4th | Faint<br>Distinct | 7 min<br>11 min | 2 min<br>4 min | 40 sec<br>2 min | 40 sec<br>2 min |
| 5th | Faint<br>Distinct | 4-7 min<br>11 min | 2 min<br>4 min | 40 sec<br>2 min | 30 sec<br>2 min |

" The time demanded for the plates to resume their original colour after being exposed to carbon monoxide varies considerably, and is amongst other things dependent on temperature and light. At the above mentioned tests the time has varied from 20 min to 2 to 3 hours.

" Hydrogen sulphide and nitrous gases have a disturbing influence on the detector. Hydrogen sulphide gives a non-reversible discoloration. Nitrous gases bleach the colour given by the carbon monoxide, but apart from that it does not destroy the detector so that it becomes unserviceable. A detector blackened by carbon monoxide can regenerate in a few minutes by exposure to nitrous gases, and this can be repeated several times without any damage to the detector."

Herzbi say that the life of these detectors when open to the atmosphere is about a month.

*Herzbi Limited, 57 Lordship Park, London N16.*

# Ergonomics, Its Purpose and Potential

**The first International Congress on Ergonomics has been held in Stockholm. Ergonomics, the science of suiting the job to the man, has made a vital contribution to productivity though, as an organized study, it is still in its infancy.**

ERGONOMICS has been the issue of a *mariage de convenance* between engineering, particularly work study and design engineering, and medicine, particularly physiology, anatomy and experimental psychology. It was a marriage made necessary, in the interests of increased productivity, by the limitations of engineering knowledge alone in assessing the types and designs of equipment, workplaces and environmental facilities best suited to human use. That the International Ergonomics Association have this week held their first international congress, in Stockholm, is a measure of the growing importance of this comparatively new applied science.

Until the last decade or so, problems of equipment and product design and of workplace and factory layout have been conceived, in most firms, as essentially engineering problems involving close attention to the needs of the hardware but little or no attention to the needs of the operators and users. The birth or evolution of ergonomics has been part of the wider realization that this machine-orientated thinking is outdated and inefficient and that production operations are basically man/machine relationships and must be studied and designed as such. In the expressive phrase of a Cornell University, USA, research worker, the man part of the relationship should be regarded as " a unique servo unit in a complete servo control system."

If production operations are to be regarded as man/machine complexes, however, it follows, since the design of man is more inflexible than that of machines and equipment, that engineers must know more about the capabilities and the limitations of man. For this reason, the rules of the Ergonomics Research Society, founded ten years ago, call ergonomics " the anatomical, physiological and psychological study of man in his working environment." Because ergonomics is thus a blending of engineering with the biological sciences it does not yet exist as an academic discipline in its own right but, for the moment, is based on empirical relationships between engineers, physiologists and psychologists.

The word " ergonomics " takes its origin from the Greek "ergon," meaning " work," and " nomos," meaning " law." In America, where classical influence is less prevalent and, in some ways, the English language is more widely recognized, it tends to be known as human factors engineering.

## CONTRIBUTION OF MEDICINE

The one branch of engineering which has always taken some cognizance of the broad principles of ergonomics is motion study—if the British Standards Institution will pardon the term. Not surprisingly, though, this was a technique developed jointly by an engineer, Frank Gilbreth, and a psychologist, his wife Lillian. In this country, their leading disciple has been another psychologist by training, Ann Shawe. The therbligs, or units of physical effort, which they evolved give consideration to the human factor in engineering but, even here, there has been some re-thinking in the light of the physiological aspects introduced by ergonomics.

In addition to this development of motion study, the work of ergonomics has been going on in its different parts for some years. During the war the Medical Research Council was called in to study the effect on men of various types of environment, and anatomists and engineers cooperated to good purpose, but only " for the duration." The physiologist has become more involved in industry through his interest in muscular aspects such as total energy expenditure, and hence required food intake, maximum permissible levels of work, muscular training and fatigue, and the relationship between level of muscular work and the surrounding conditions of temperature, humidity and air movement.

He is also interested, for example, in studying the diurnal rhythms of the body during shift work when the efficiency of operator performance may be impaired until the body adjusts physiologically to the new pattern of activity. Most people take four or five days for their rhythm to invert and it is therefore likely that weekly changes of shift are socially and economically bad. However, more research is needed on this point.

Other factors which have been considered by the physiologist—and which he has contributed to the overall study of ergonomics—are the effect on operators of increasing age and a study of posture and human seating. This last field is probably one of the widest known of all aspects of ergonomics and the Ergonomics Research Society is represented on the British Standards committee for school furniture.

The contribution which the experimental psychologist has brought to ergonomics is his concern with man as a control mechanism or communication system taking in information from his surroundings through his sense organs, storing it and using it to guide his actions. He has studied, and is studying, the relationship between fatigue and boredom; man's perceptual ability in relation to the growing demands of automation and process work; the comparative merits of visual and audible signals; the importance of " feel " in the handling of controls; the fallibility of human memory, particularly in the short term; the impact of complex displays; effective sizes of instrument markings; and the relationship between displays and controls.

## PRACTICAL APPLICATIONS

The knowledge gained from such physiological and psychological research is obviously of great value to both the design and production engineer. How much more efficient might machine tools be from the operator aspect, for instance, if this knowledge had been available to engineers a few decades ago. The same point is valid for many cars and household appliances.

Ergonomics is already making a significant impact on industrial practice. In work study, it is becoming recognized that the giving of percentage fatigue allowances is inefficient and should be superseded by rest pauses at physiologically the right moment. Ergonomics is also producing new thinking in motion study and, at the Urwick Management Centre for example, new principles are being evolved on operator hand movements, the emphasis now being on " sympathetic " rather than " symmetric " movements. It has also called in question the fact that motion study takes no account of " no movement," yet physiologically the operator may be undertaking much muscular work.

Design engineers have learned from a knowledge of ergonomics the importance of the relationship between the direction of movement of a control and the effect which the control produces. Controls and their associated effects which conform to a normal and usual pattern, called a " population stereotype," are said to be " compatible." They have the advantages of being easy to learn, not being a distraction and being likely to fit in with an operator's immediate reaction in an emergency. By applying psychological knowledge, it has also been possible to design control equipment which does not place a surveillance overload on the operator and therefore increase the danger of accidents.

It has also been possible to make visual indicator design more effective and to compare the relative merits, in given circumstances, of (*a*) moving pointers travelling over a fixed scale; (*b*) fixed pointers seen against a moving scale; and (*c*) counter indicators. Much is known, too, about the needs of scale shape, size, colour and numbering. Research has also been carried out on representational indicators, such as in aircraft cockpits, but more is needed.

Lighting is another subject which has been covered more fully with the increased appreciation of the importance of working environment. In particular, important work has been carried out at the Building Research Station on light levels required for adequate vision, the effects of glare and dazzle, and the use of light to make the workpiece or working area the natural focus of attention. The Building Research Station has evolved a type of lighting, called permanent supplementary artificial lighting, which is a mixture of natural and artificial lighting of a strength and consistency which might make it ideal for high density factory building.

In the steel industry, much ergonomics research has been carried out, sometimes through the British Iron and Steel Research Association's advisory service, on human efficiency in hot conditions. It has been possible to improve productive efficiency by the provision of protective clothing and equipment. Major work has also been done on the design of, and visibility from, the cabs of overhead cranes.

## THE FUTURE

Thus ergonomics has already been of wide use in stepping up industrial productivity, but its application has so far been sporadic and limited to particular industries. This is largely because, as a whole, it is a fairly new mutation developed from sciences and techniques that have not yet fully established their points of contact. However, as did biochemistry, another hybrid science, it is likely to develop rapidly once these points of contact have been established more effectively and it begins to grow into an integrated subject.

Following the lead of the Warren Springs Laboratory most of the DSIR assisted research stations are working on ergonomics and have increased this work vastly during the last few years. Enough research has now been carried out to prove that ergonomics is an economic necessity and that, given continued cooperation between the engineer and the physiologist and the experimental psychologist, there is scope for much more research. We are only just beginning to establish the ergonomic truths about such vital subjects as shift working and the changing capabilities of older workers—one day of the Stockholm Congress has been devoted to this latter subject.

The future of ergonomics as an effective design and production tool depends more, though, on the application of these research findings to the shop floor. If industry is to draw maximum benefit from this new technique, it is vital that the good work of the laboratory should be taken up in the design and production departments. For this reason it is necessary that more engineers should be trained in ergonomics, on such courses as those at Loughborough and Cranfield, and even on undergraduate courses.

A considerable amount of data is now available on ergonomics research work. Articles on the data available at that time and written by Mr. K. F. H. Murrell were published in ENGINEERING on 16, 23 August, 6, 13 September and 4 October, 1957, and are available as a reprint, *Data on Human Performance for Engineering Designs* (3*s*). Some of the material for this article has been obtained from the recently published report (12*s* 6*d*) on the DSIR conference on " Ergonomics in Industry " held in September, 1960. The European Productivity Agency also held such a conference in 1959.

## Fabrication Problems with Tantalum

Tantalum is a rare metal which, though comparatively expensive, is well suited to chemical plant construction in that it has high corrosion resistance. In particular, Royal Dutch/Shell are studying methods of using it as liners for large pressure vessels since its cost would not be prohibitive when employed as a thin internal coating only.

Unfortunately, though, there is a very limited amount of know-how available on ways of fabricating tantalum. It is a difficult metal to weld because it cannot be welded in the presence of

*Welding tantalum in an inert atmosphere of argon.*

air without becoming brittle and, further, it makes an imperfect bond with steel.

To overcome the problem of making tantalum welds in air, Shell engineers have adapted techniques of welding in an inert atmosphere of argon, similar to those used for welding titanium. However, more accurate control of the welding condition is necessary because tantalum has a melting point of about 5,425° F and a strong tendency to warp. To counter this warping, jigs and fixtures are used so that the back of the weld can be protected with argon.

In this way, simple welds can be made in the atmosphere, provided all parts of the joint near the torch are shielded with argon, though objects of intricate shape are best welded in an argon filled chamber or welding box. The same method is advisable for the welding of connections to tubes of small diameter.

Since tantalum cannot be welded to steel the attachment of a tantalum liner to a steel vessel requires special techniques. Methods are being developed similar to those used in the construction of titanium linings, where strips of titanium are riveted to the inside of the vessel. Grooves of about 9 mm are left between each pair of parallel backing strips to serve as channels to distribute the argon supply. Argon reaches these channels when it is fed to the reverse side of the weld through holes drilled in the steel wall of the vessel. The panels of lining material are attached to the backing strips by spot welding and linked by overlapped fusion welds.

*Shell International Petroleum Company Limited, 1 Kingsway, London WC2.*

## De-stressing Continuous Railway Lines

A cheaper and more efficient method of de-stressing continuously welded railway lines, using specially designed air-propane burners, has been adopted on the Eastern and Southern Regions of British Railways. The burners, are used to warm the rail to between 65° and 75° F before it is fastened down. This enables the continuous rail to withstand subsequent stresses of expansion and contraction in varying weather conditions.

Of the heat sources experimented with for heat de-stressing, propane has been much the most successful, largely because it is easy to handle and has a high vapour pressure at low temperatures. The air-propane unit consists of a trolley supporting four heating muffles and four 100 lb propane cylinders, each muffle housing two air-propane burners fed from the cylinders.

The operation entails moving the trolley slowly along a section of track with the heating muffles directed against the continuously welded rail, and the temperature rise is assessed by measuring the amount of expansion. When the temperature of a 500 yd length of rail is raised from just over freezing point to 70° F, it expands approximately 4 in. This heating operation would take about 1¼ to 1½ hours.

Dispensing with rail joints gives considerable saving in wear and tear of fastenings, rails and rolling stock and cuts down track maintenance, so long as the ballasting is adequate. It will also change—or eliminate—the clatter.

*The British Oxygen Company Limited, Bridgewater House, St. James's, London SW1.*

## Stress Relief of a Reactor Vessel

The first of the 70 ft diameter reactor pressure vessels at Hunterston Nuclear Generating Station has now been successfully stress relieved. This involved heating to a temperature of 550° C about 1,800 tons of steel, at a mean height of 85 ft above ground level, soaking it for 12 hours and then allowing it to cool slowly. Careful control was vital to prevent the temperature difference between any two points in the vessel exceeding a specified maximum.

Installed inside the pressure vessel and undergoing stress relieving at the same time were the inner heat shield, the core-support grid, and the main gas seal between the walls of the inner heat shield and the pressure vessel. Parts of the hot and cold gas ducting and the nozzles for the

*Installing electric heating strips under grid.*

charge/discharge and control-rod standpipes which penetrate the pressure shell were also included in the operation. The steel restraint beams for the graphite core were suspended from the inner shell nozzles, and other items treated at the same time were laid on top of the grid cover plate.

The pressure vessel and included components were heated by a series of freely radiating Brightray alloy strips supported by wire links and ceramic insulators. Some strips were mounted circumferentially between the spherical pressure vessel and the cylindrical inner heat shield while others on the top and bottom crowns followed approximately the curvature of the vessel. The method of suspension of the heaters was very flexible and permitted switching off of individual heaters without damage to the suspension of other heaters.

Temperatures were measured at about 400 points by means of chromel-alumel thermocouples. All the internal and external positions for the permanent thermocouples were used, together with a number of temporary points, readings from them being recorded by two different instrumentation systems.

Particular attention was paid to the positioning of thermocouples on the pressure vessel support skirt, gas-duct stubs and sphere. It was possible to record the temperature distribution down the support skirt in various planes around its periphery, enabling a check to be made on the performance of the thermal pocket at the top of the skirt.

The vessel could be symmetrically divided into four quadrants, so it was reasonable to assume that the heating pattern would be similar in each quadrant. It was therefore decided to connect strip-chart recorders to the thermocouples in one quadrant only, with a few check thermocouples in the other quadrants.

As there was no previous experience to draw on for controlling the heating rate of vessels of this size and complexity, it was not possible to lay down a set of rules governing the operation. Initially, the bottom crown heaters were switched on at their lowest setting—half load—and held at this level until the heating pattern emerged. The switching instructions were then held on this pattern.

It was agreed to limit the rate of temperature rise to less than 5° C per hour and on this basis it took about seven days for the pressure vessel to reach the stress relieving level of 550° C at which it was soaked for 12 hours. As would be expected the overall rate of heating was controlled by that of the bottom crown, because natural convection tended to take the heat away from this part of the sphere. After the soaking period the vessel was left to cool for nine days before removing the thermal insulation. Entry into the vessel was delayed for a further two days.

Subsequent tests have shown the stress relieving to have been entirely successful. Some minor modifications to the layout of the heating system should result in a reduction in treatment time on the second reactor vessel. However, the use of radiant heating strips has been a success.

*General Electric Company Limited, Erith, Kent.*

## Shipyard Handling by Tractor

At the Cartsdyke shipyard of the Greenock Dockyard Company, a Fordson Industrial Super Major tractor is now being used for short-hauling massive prefabricated steel parts. It is being used as a haulage link between the prefabricating hangar and ground positions along the length of the slipways. The parts are then swung from the tractor's 10-ton transporter trailer up to the ship for welding into position.

For the moment the tractor is using rear wheel weights of 8 lb each specially made, as a temporary expedient, to enable the tractor to bite into the deep loose shale which forms part of the yard pending completion of a tarmac surface extension. Loads of up to 40 tons at a time are frequently towed across the present difficult surface.

*Ford Motor Company Limited, 1 Ley Street, Ilford, Essex.*

*Hauling a bridge section to the slipway.*

# On the Shelf

*By Frank H. Smith*

I'VE HAD a news release from the Institute of Aerospace Sciences that the head of their Technical Information Service ( I used to know him as the librarian) is one of a five-man mission (consisting of the heads of the major abstracting and indexing services) that the National Science Foundation is sending to Japan to find out how their systems operate. The NSF is, of course, one of the better known bottomless pits which the American Government keeps full of dollars, topping up whenever the surface falls two inches. All the same, this world-wide interest in Japan is going to give the Japanese quite a bit to live up to. Such as being Top Menace of the future.

The Library Association; Reference, Special and Information Section (North Midlands Group) have sponsored (if that be the word) a (an?) *Union List of Current Commercial and Technical Periodicals in the North and East Midlands*, edited by D. W. Bromley, of Nottingham P.L., and D. E. Clarke, of British Manufacture and Research Company, at 12*s* 6*d*, from D. W. Bromley, Commercial and Technical Library, Nottingham Public Library, South Sherwood Street, Nottingham, and I would like to thank the aforesaid gang for making the bare announcement so lengthy that I have neither need nor room to say anything more. I will add, though, there are 3,000 periodical titles.

I have mentioned before the Union of International Associations (the antithesis of digest of digests?) at Palais d'Egmont, Bruxelles, 1. They have sent us (and by us I don't mean me) a copy of *Congress Organizer's Manual*, by Lucien R. Duchesne, at $4 or 21*s*. Not a bad exchange rate either. I cannot start to describe this exhaustive book (100 pages) but if ever I run a congress I shall get a copy of it—and then back out.

I do not often get a publisher's announcement from HMSO but I did get one (Yours sincerely, Frank Davey—which is nice from a civil servant) for *Current Trends in Scientific Research* by Auger at 33*s*. It's a UNESCO sponsee (if not sponsee then what *is* something that is sponsored? Which reminds me that newspapers refer to prison-breakers as escapees !) or sponsation.

Those assiduous catalogue producers G. B. Film Library (1 Aintree Road, Perivale, Greenford, Mdx.) have brought out *Industrial Training Films and Filmstrips* (I always wondered what a strip joint was), which comes with full particulars of hire and a built-in agreement form.

One does not get a lot of humour in the engineering world so it may be worth noting *On being an egghead; or engineermanship for the shell of it*. This is a book of zany off-beat cartoons, the characters of which have the shape of hen-fruit. The captions take sly swipes at methods of getting on in the world, and while the book may not be useful for the library shelf it may take the candidate's mind off what's cooking while he is waiting for an interview with the personnel officer. $3 a copy in the States; E. J. Petherick, of Benson-Lehner (G.B.) Limited, West Quay Road, Southampton, will let you have a copy for the sterling equivalent.

In a recent supplement called *The Times Survey of the Architect in Britain Today*, the R.I.B.A. secretary, writing on "Changing Role of Royal Institute," says "The R.I.B.A. library, as a repository of learning and a direct relevant tool for the practising architect at his drawing board, remains by common consent one of the two finest architectural libraries in the world. Education and training (and, increasingly, research) necessary in any practice, call for penetrating analysis and imaginative action, and therefore the library remains the basis of the institute's activities." Those last nine words should be engraved in six-foot letters somewhere or other but, for the moment, I cannot think of anywhere prominent enough.

# Wonder Book of Spacemen

**Seven into Space: the Story of the Mercury Astronauts.** By JOSEPH N. BELL. *Ebury Press, 30 Grosvenor Gardens, London SW1.* (12*s* 6*d*)

Facetiousness is a dangerous commodity. The acknowledgement page of this book finished with the sentence: "Gratitude is also due to the Russians, who thoughtfully failed to orbit a manned satellite while this book was in preparation." They failed to be so accommodating between passing of proofs and publication date. Both Major Gagarin and Commander Shephard have been up and down before this book reached its readers on this side of the Atlantic; Captain Grissom made the second flight for the United States before this review was written and Major Titov for Russia before it was published.

Such are the hazards of writing topical books about space travel. The author has further worsened the odds against himself by writing two whole chapters about imaginary flights as recorded by spacemen. In some ways these are among the better chapters in the book (and remarkably close to what has been recorded since by astronauts in actual flight) but of course he has been beaten by the real thing and the impact is spoiled in consequence.

This is not a technical book. It is a racy, readable and in places naive account of the choice and training of the seven American astronauts. Treated as a series of magazine articles it is diverting and informative. Judged by any higher standard it is irritating and uncouth. The book is aimed at the average American who is assumed, probably rightly at the time of writing the book, to be ignorant about space travel and uninterested in its technical and political significance. To get and hold his attention most of the tricks of modern American journalese have been mobilized. The word "dedicated" is worked to death and sorely misused in the process. "World War Two" is contracted in one case to "W.W.II" to show, presumably, what a hurry we should all be in to forget the fact and get into space.

There are brief biographical details about the seven men, adequately but not very imaginatively done. The author is fair in his comments on the Russians, and justifiably worried about their achievements. He is out to shake up apathy and he finishes with a strong criticism of the lack of urgency in the US space programme although the book offers little in the way of systematically displayed evidence to support it—true as the accusation may be.

G. E. TEWSON

# Signals and Communications

**Fundamentals of Signal Theory.** By JOHN L. STEWART. *McGraw-Hill, New York and London.* (70*s*)

**Statistical Theory of Communication.** By Y. W. LEE. *John Wiley and Sons, New York and London.* (134*s*)

Although the subject matter of both these books can probably be found distributed here and there among other publications it is pleasing to see it collected together and appearing concentrated into two books. In many ways these books are complementary, and while they do cover some of the same topics, they have a different approach. They are obviously aimed mainly at the student around the graduate stage, although no one should therefore think they are too elementary. Both books give a healthy build-up of the modern mathematical tools available and both give plenty of problems on which the reader can practice the art. Both authors have tried to build up the mathematical techniques around the physical problem and largely tried to interpret the mathematics in terms of the physics. Both books are well indexed but do not contain very extensive bibliographies.

J. L. Stewart's book starts off by introducing the use of vectors and sinors for transfer functions, then briefly covers graphical and locus methods used for expressing networks properties. Complex algebra and the use of exponentials and logarithms is then developed and applied to networks.

The properties of sets of differential equations are then summarized bringing in determinants, matrices and the "p" operators. Some of the effects of physical limitations are developed. The concept of poles and zeros is introduced and connected with the properties of physical networks. It was somewhat disappointing to find no serious attempt had been made to give a physical significance to the concept of complex frequency; after all, surely this is a more natural concept than "real" frequency. The book continues by developing various algebraic approaches to the pole and zero position problem. Methods of factorizing polynomials are considered. Methods of expansion into partial fractions and continuous fractions are developed thoroughly.

The next subject in this book is that of the methods of approximation to obtain some required transfer function. The Taylor approximation method, Butterworth and Chebyshev methods are discussed. Linear phase approximations are covered with some detail, demonstrating the use of a Padé table. Frequency transformation for BP filters and other more direct design methods are indicated.

Up to this point in the book the emphasis has been on the amplitude and phase response of networks and about half the volume has been occupied. Time responses are now discussed using expansions, approximations, and general properties are investigated. Methods of solution with complicated input functions are covered. The Laplace Transform is introduced and its connection with the Fourier Transform is presented. The algebra of contour integration is developed as required for the physical problem. Various theorems are developed and illustrations given of their use. Some of Bode's general relationships between phase and amplitude are derived at some length using Hilbert transforms but the physical significance is missed. The importance of these theorems cannot be over-emphasized as they often prevent someone trying to design a network to do the impossible. It is a pity that there is no introduction to branch points in the section on contour integration as this does allow other important similar relations to be derived.

The last two chapters of the book give a thorough discussion of Fourier Series, modulation and spectra, leading on to the Fourier Transform. This appears as an addition to the rest of the material, which it really should not do of course. It is in fact a very important part of the whole story and could with some advantage have been brought in before the chapter on Laplace Transforms. In fact, the limitations of Fourier lead naturally to the Laplace. This suggested approach would have had the advantage of removing some of the "magic" from the Laplace Transform and putting it on its right level.

The last 20 or 30 pages of the book seem out of place somehow and although the development of the properties of random functions, probability, power spectra and Weiner's matching problem would seem to follow from Fourier Transforms, so does aerial theory, etc., etc., which J. L. Stewart has not covered. This part should have been left to a book of its own, like Y. W. Lee's.

In spite of these criticisms this is a thoroughly recommended book. The author has connected

up most of the mathematical techniques with physical concepts but somehow has missed taking full advantage of this on some of the more important techniques.

As indicated above, Y. W. Lee's book (509 pages) deals with the same subject as the last 30 pages of Stewart's book, but of course developing it to a much greater depth.

He starts with the Fourier Series, relates it to correlation, auto-correlation and cross-correlation. This is all done with non-random periodic functions and thus the meaning of these processes is made very clear. The relation between convolution and correlation is emphasized and the differences pointed out. The subject is expanded to cover non-periodical and non-random functions. Having made clear some of the basic mathematical concepts he then passes on to random functions. He shows how the power spectrum and auto-correlation function of "noise" are related. The relation between Fourier spectrum and power spectrum is proved and applied. Probability is then discussed leading to the stationary ensembles. Averages, moments, distributions are all developed around practical problems. Time averages and ensemble averages are compared. Auto-correlation of time functions, for example, pulse modulation, etc., is described.

The book is full of useful summaries, which act as very good means of recapitulation as well as good reference points.

So far this occupies about half the book and has been largely a development of the tools. The second half is generally speaking applications of these tools to more specific problems. The second half starts by going into the question of the actual measurement of correlation and probability. This naturally leads into the theory of sampling. Then such problems as detection of a periodic signal in noise by correlation are studied. This is backed up by some photographs of actual experiments.

A chapter follows on applying random inputs to linear systems, trying to attach physical significance to auto-correlation. Special cases of random pulses are considered. This gives the background to lead into the design of optimum linear systems, using the calculus of variations. Poles and zeros are applied to power spectra and used to develop the method of spectrum factorization. The application of the optimum filter to prediction is developed and then errors in optimum systems are discussed.

The last chapters, which perhaps are more in the nature of an appendix, develop the use of orthonormal functions to represent correlation functions and power spectrum and then uses them as a possible means of design of optimum filters.

It is difficult to put over in a review the inspiring way this book is written. The author has consistently managed to give physical significance to all the mathematical processes he uses. He is obviously an enthusiast for putting the subject over well, and in the reviewer's opinion he has succeeded.

P. S. BRANDON

# Engineering and Electron Microscopy

**The Electron Microscope: the Present State of the Art.** By M. E. HAINE. *Spon.* (55*s*)

Dr. Haine was for a number of years in charge of a research group which has helped to maintain Britain's leading position in electron microscopy. Although the sub-title of the book implies that the design and construction of electron microscopes is still an art, the author and his colleagues have done much to turn this art into a science.

The book is unique in that it provides a useful introduction and background to the electron optical and mechanical problems facing the designer of electron microscopes at the present time. The electron optical data is mainly set out in graphical form while the underlying mathematics has been excluded as far as possible; references to the relevant literature being adequate though not comprehensive.

Apart from the electron optical and mechanical problem, three chapters deal with the wave optics of the electron microscope; again the mathematics is kept to a minimum and this will assist the non-specialist to acquire at least a comprehension of a difficult subject.

The last chapter of the book was written in collaboration with Dr. V. E. Cosslett, one of this country's leading electron microscopists who has contributed prolifically to the literature. This chapter provides a useful survey, with a detailed list of references, of the techniques used in specimen preparation, and in a section on applications some beautiful photographs are reproduced, especially of biological specimens. Although only one page is devoted to metallurgical applications it is emphasized that this field of study has recently become very important following the development of refined techniques for specimen and replica preparation.

The author's clear exposition and mode of presentation make the book invaluable for practising electron microscopists who wish to obtain a deeper understanding of the microscope, and the utmost performance from their instruments. A sense of completeness has not been achieved because of the omission of a section on the specialized electronic circuitry which is required for the very stable high voltage and lens current supplies, but this is the only important criticism that this reviewer has to offer. More thorough proof-reading would have revealed a few trivial errors in the text and figures, but these should not give rise to any confusion.

Electrical engineers have contributed largely to the development of the electron microscope, but important mechanical engineering problems remain to be solved.

The theoretical limit of the resolving power as set by the lens of the electron microscope is about 3Å (about $10^{-8}$ in), while the best practical resolving power that has been achieved is 6 Å. If the theoretical limit were attained, there would be a distinct possibility that atoms could be seen directly and this would be a remarkable scientific achievement.* One of the barriers which must be overcome arises from instrumental instabilities which cause the image of the specimen to move during exposure to the electron beam. Apart from the possible instabilities due to varying electrical and magnetic fields and thermal effects, the main causes of the instability are the vibration of the specimen holder or mechanical specimen stage, a slow drift of the specimen holder, and flexing of the microscope produced by vibrations.

* ENGNG, 21 July '61, p. 94 "Plans for a Large Electron Microscope" by Franks and Halliday.

The physical and mechanical requirements for the specimen stage are very severe: the specimen must be moved a distance of over 1 mm in two coordinate directions and its position must be set to about 0·1 micron; once in position, it must remain stationary within about 1 Å for 30 sec. No wholly satisfactory design has been achieved and Dr. Haine categorically states that the basic problem is too difficult to solve by logical kinematic engineering methods and that in fact the application of such methods tends almost to prove the impossibility of obtaining a solution. This indeed is a challenge to all instrument engineers! Relatively few engineers are even aware of the existence of such problems and this is doubtless due to inadequate liaison between engineers and physicists. An entirely different field where engineering experience would benefit electron microscopy is in the construction of electron lenses. Some attempts have been made to improve the quality of the lenses but this has not been seriously pursued.

In general, engineers have not yet made sufficient use of the electron microscope as a tool for investigating problems of technical importance. In this country, problems relating, for instance, to wear and lubrication are studied at very few laboratories. The indications are that in the United States there has been a much better appreciation of the potentialities of the microscope and in one case publicized recently, an American railroad company improved its operating economy by routine use of an electron microscope in the study of diesel oil sludge.

It is through the medium of such books as this that different disciplines can be brought together to the benefit of all.

A. FRANKS

# The Most Unforgivable Sin

**The Spring.** By ILYA EHRENBURG. *MacGibbon and Kee.* (18*s*)

Ilya Ehrenburg is a Russian whose name is often mentioned in left-wing intellectual circles and in the literary columns of highbrow newspapers and periodicals. Now 70 years old, Mr. Ehrenburg has twice been the recipient of the Stalin Prize (1942 and again in 1948) and is one of the rare "old-guard" Soviet authors to have survived the various purges. Having lived on the Continent from 1921 to 1940, he is regarded by the literary establishment as being the most cosmopolitan of living Russian writers.

In first *The Thaw*, and now in its sequel *The Spring*, he has attempted to trace the lives of a number of contemporary Russian provincials; in so doing, states the publisher's blurb, he presents a "vivid, convincing and unself-conscious picture of life in Russia today, and of the struggles and aspirations of her people, the workers, doctors, engineers and artists who make up a typical community"'

Unfortunately, I have never lived in Russia.

But my parents were born and spent their formative years there, and from them I garnered some idea of Russian life during the pre-revolutionary days. Although they differed over trivia, my father and mother were agreed on one major point: that the personality types to be found among the Russian people of those days were not too unlike those found in other lands; that a butcher in Kiev resembled his counterpart in Philadelphia or Birmingham. At the time, this premise sounded fairly reasonable.

Then I began to travel: university in France; extended periods of residence in Spain, Italy, Sweden, Denmark, and now England. Experience has taught me to agree with my parents in this respect. Though I have been aware of the national peculiarities and customs that differentiate one country from another, I have been even more struck by the similarities shared by various peoples. These have been much easier to assimilate since they are so much more prevalent.

Now, having read Mr. Ehrenburg's two novels, I can conclude but one thing—the Russians have suddenly, since 1917, evolved into the most remarkable race on the planet.

The "workers, doctors, engineers and artists" who people Mr. Ehrenburg's books are unlike any workers, doctors, engineers or artists I have

ever encountered outside of his pages. His characters are all dedicated religionists, continually consecrated to the Communist vision and the coming of the Marxist millenium. No questioning, no doubting, not even during their most philosophical moments. Even love and marriage (but never sex) are shown to serve The Revolution. And the Soviet peoples march diligently and unselfishly along the road to Communism, the Glorious End.

This is a most extraordinary picture. If true, then they are not to be denied.

Evolution will have produced its most superior specimen; the rest of us must pay homage to the new masters. If true—

But is this the true picture or merely the officially and tactically correct one? A curious feeling which persisted during the reading of these works was that they had been written not for the Russian or Communist reading public but as a show piece for foreign audiences.

It may be that I am a bourgeois product, decadently unable to envisage a society and people so radically different from those with which I have had contact. It may be that I and my kind should be liquidated in order to ensure the more rapid advance of their glorious new world. Or perhaps Mr. Ehrenburg is not wholly accurate.

For there are Russian writers who report something a bit different. During a brief period in the mid-1950's, Communist Party restrictions regarding the arts and literature were temporarily relaxed as an experiment. Several exciting and well-crafted novels which have subsequently been repressed and condemned within the Communist sphere were published at that time. *Not By Bread Alone*, by Vladimir Dudintsev, was one of these works; it also describes the lives of "workers, doctors, engineers and artists."

But these are much different from those who people Mr. Ehrenburg's books. In fact, Mr. Dudintsev's people are not so unlike some American and English workers, doctors, engineers and artists with whom I am acquainted. His story reads quickly, smoothly and stimulatingly, very much in the grand Russian tradition.

Unfortunately, Mr. Dudintsev has had to suffer for his skill and honesty. He now lives in isolation, shunned by the official writing societies and publishers; no further work by him has appeared. He lives in much the same state of ostracism as did Boris Pasternak after the publication of *Dr. Zhivago*. Mr. Dudintsev must have known of the possible dangers associated with his writing and publishing *Not By Bread Alone*; yet he still had the moral courage necessary to decide to go through with it. At least he has the reassurance of knowing that he suffers for the sake of his own truth.

Mr. Ehrenburg needs no such reassurance. He is well paid, much travelled, respected and publicly commended by the official Governmental bodies in Russia. He is also honoured and revered overseas by those who know of him only through his official reputation and publicity.

Now I may be a cynic, or a suspicious person. I may even be a muddled-thinking brainwashed capitalist. But my eyes tell me that Mr. Ehrenburg is a fraud; they shout to me that he is a mediocre writer, a hack whose techniques and modes of expression are näive, out-dated, insincere and incredibly insulting to any reader of normal intelligence. Worst of all, they say, he's a wretched bore. They are my eyes; I must follow them. And boredom is the one sin they never forgive.

DAVID CHAGALL

## Trade Publications

*Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.*

### *Materials*

**Transformer and Switch Oils.** CASTROL INDUSTRIAL LTD., Castrol House, Marylebone Road, London NW1. Guide to the subject. Refers to relevant British Standards. 42 pp., ill.

**Condenser Process.** CRANE PACKING LTD., Slough. Gives up-to-date information on the Crane condenser tube assembly process with brief details of fitting and tools. 12 pp., ill.

**Silicon Carbide Heater Elements.** MORGANITE ELECTROHEAT LTD., Point Pleasant, Wandsworth, London SW18. Uses and design data for Crusilite heater elements. 13 pp., ill.

**Rings and Circular Die Forgings.** TAYLOR BROS. AND CO. LTD., Trafford Park Steel Works, Manchester 17. Rough guide to what this company will undertake in steel. 16 pp., ill.

**Vermiculite.** MANDOVAL LTD., 33 Gresham Street, London EC2. Claimed to be the first comprehensive handbook on vermiculite and uses in building and other industries. Data on composite products. 40 pp., ill.

**Mastic.** HODGSON, SCOTT AND CO. LTD., Wilbert Lane, Beverley, Yorkshire. Sealbead is a knife-grade synthetic butyl rubber mastic for double glazing and curtain wall construction. Introduction. 2 pp., unill.

**Silicones in Electronics.** MIDLAND SILICONES LTD., 68 Knightsbridge, London SW1. Summary of uses of silicone rubber, varnish, fluids, etc. Little technical data. 20 pp., ill.

**Pvc Pipe.** ALLIED STRUCTURAL PLASTICS LTD., Tolpits, Watford, Herts. 'Aspect' pvc pipe is made from medium impact rigid pvc. There are fittings and pipes of three classes, suitable for working heads of 200, 300 and 400 ft. Sizes and prices. 12 pp., ill.

**Aluminium Flooring.** ALCAN INDUSTRIES LTD., Banbury, Oxon. Noral Treadplate is a flooring material with a pattern of raised lozenges, claimed to provide safe foothold under many conditions. Data on loading and alloys. 8 pp., ill.

**Plastics.** NYLONIC ENGINEERING CO. LTD., 311b Rayners Lane, Pinner, Middlesex. Expanded version of this company's literature on industrial plastics gives practical design data. This may vary slightly from what individual makers recommend but is based on practical experience. 48 pp., unill.

**Plywood.** TIMBER DEVELOPMENT ASSOCIATION LTD., 21 College Hill, London EC4. This is a revised edition of the 1958 one. Data on design with plywood for choice of the correct grade, but no directory of suppliers. 48 pp., ill., price 5*s*.

**Plastic Foam for Buildings.** FLAMINGO FOAM LTD., 34 Victoria Street, London SW1. Flamingo foam is an expanded polystyrene. The company is associated with Monsanto. Data on what to expect from the foam and how to use it. 16 pp., ill.

**Foam Control with Silicones.** IMPERIAL CHEMICAL INDUSTRIES LTD., Millbank, London SW1. A few examples of their use. Data on appropriate fluids. 9 pp., ill.

## New Books

**Britannica Book of the Year, 1961.** *Encyclopaedia Britannica Limited.* (£5 5*s*)

The personalities and main events of 1960 are surveyed in 423 contributions.

**The International Year Book and Statesmen's Who's Who, 1961.** Edited by H. T. F. RHODES and C. J. SMITH. *Burke's Peerage Limited.* (£8 8*s*)

Part 1 contains an article on international cooperation in engineering, a directory of international organizations and a series of charts showing the organization of the foreign ministries of the UK, USA, France, USSR and the People's Republic of China. Details of the various states are given in Part 2, while Part 3 is a "Who's Who of the World."

**BDI [Germany Supplies, 1961-62.** 5th Edition. *Gemeinschaftsverlag GmbH, Postfach 508, Darmstadt, Germany.* (50 *DM*)

This is the official export directory of the Federation of [West] German Industries, containing over 70,000 entries in German, English, French and Spanish and giving detailed information on suppliers of all types of consumer and producer goods. An alphabetical register of German manufacturers and a list of important trade marks complete the edition.

**Electrical Trades Directory, 1961.** 79th Edition. *Benn Brothers Limited.* (70*s*)

Among the sectionalized information contained in this year's enlarged edition are the details of over 5,000 manufacturers and other companies, some 3,500 electrical installation contractors and upwards of 4,000 engineering firms of various categories. The products listed number some 2,800.

**Packaging Directory, 1961.** *Tudor Press.* (21*s*)

Comprehensive guide to all aspects of packaging in Europe. Worth remembering is the 40-page directory of trade names.

**Guide to the Coalfields, 1961.** Edited by G. R. STRONG and E. G. CORBIN. *Colliery Guardian Company Limited.* (20*s*)

Mines, personnel, trade unions, learned societies and associations are detailed. Reorganization within the NCB has again resulted in extensive revisions to the current Guide.

**Lloyd's Register Book, 1960-61.** Volume 4: Directory. *Lloyd's Register of Shipping.* (60*s*)

Details are given of shipbuilders and existing ships built by them, boilermakers and marine-engine builders; docks (wet and dry) and harbours; and marine insurance.

**Introduction to the Dynamics of Automatic Regulating of Electrical Machines.** By M. V. MOEROV. *Butterworths.* (100*s*)

Well over half the book, which is a translation of the first Russian edition (1956), is devoted to the theory of linear systems with continuous action. The foundations of the theory of intermittent control are given a chapter, while the remaining fifth of the text is concerned with nonlinear systems. An extensive bibliography—mainly of Soviet contributions—is appended.

### *The Reviewers*

Mr. G. E. Tewson, M.A., is a partner in the firm of O. W. Roskill, Industrial Consultants.

Mr. P. S. Brandon, M.A. (Cantab.) is head of the Mathematics and Systems Analysis Laboratory of Marconi's Research Establishment, Great Beddow, Essex. He is an A.M.I.E.E. and an A.Inst.P. and teaches a post graduate course on signal theory at the Mid-Essex Technical College.

Dr. A. Franks is a Principal Scientific Officer at the National Physical Laboratory, Teddington, where he is engaged on research on X-ray crystallography, electron micro-probe analysis and electron microscopy. He is a Fellow of the Institute of Physics.

Mr. David Chagall is a novelist, whose *Diary of a Deaf Mute* has been published in several languages. He is a *licencié* of the Sorbonne, and graduated from the Pennsylvania State University in physics and psychology. He has worked on the advertising staff of a large American pharmaceutical corporation and as an assistant editor for an electrical journal.

**Ecology of Inland Waters and Estuaries.** By GEORGE K. REID. *Reinhold, New York; Chapman and Hall, London.* (72*s*)

The elemental factors and processes that operate in lakes, streams and estuaries considered as dynamic systems are presented in a way that should appeal to the student taking his first taste of the subject.

**Manufacturing Data Processing Handbook.** *Gille Associates, Inc., 22nd Floor, Book Building, Detroit 26, Michigan.* ($15)

Case histories are presented of data processing methods (involving primarily punched cards, punched tape and computer systems) currently in use in commerce and industry in the USA. The contributions fall into the following broad groups: accounts payable, billing, inventory control, order processing, payroll, production control and sales analysis.

**Civil Engineering Reference Book.** 2nd Edition. Edited by J. COMRIE. 4 Volumes. *Butterworths.* (£17 17*s*)

New chapters are included on hydraulic power plants, overhead transmission lines, structural and prestressed concrete, masonry and brickwork, and the aesthetics of bridge design. All the chapters retained from the 1st edition have been thoroughly revised.

**Surveying.** By W. NORMAN THOMAS. 5th Edition. *Edward Arnold.* (40*s*)

Considerable changes have been made to bring this standard textbook and reference work up to date. For example, the chapters on field astronomy have been brought into line with changes in the Nautical Almanac Office Publications, improvements in instrument design are taken into account in the sections on the theodolite and the level, and stereophotogrammetry is dealt with fairly fully. The geodimeter and tellurometer get a brief mention in an appendix.

# Marketing

## ICOS Process to be Promoted in UK

A new company, ICOS (GREAT BRITAIN) Limited, of Windsor House, 46 Victoria Street, London SW1, has been formed to promote the ICOS (Impresa Costruzioni Opere Specializzate) process in this country.

First developed in 1938 and based upon researches and ideas of Dr. Christian Veder, the technique is, basically, a method of constructing walls or diaphragms in reinforced concrete, or structurally plastic material, in the ground before any excavation is opened up in the normal way. This result is attained without elaborate pile-driving equipment and the only plant required is essentially a grab which in a series of passes cuts a trench to the required depth. This by comparison is virtually unlimited.

For its success, the process depends on the thixotropic properties of bentonite mud which is pumped in as the excavation progresses and prevents the caving-in of the walls. When completed, the narrow trench is filled with concrete which enters at the bottom and causes the bentonite slurry to rise and overflow at the top.

The process possesses many advantages over traditional methods, the most important, perhaps, being its quietness of operation and it is claimed that the noise level created is no higher than that associated with normal city traffic. This is of paramount importance on the site of the first application in Britain which is on the construction of the underpass for the Hyde Park Corner scheme. Here, excavation is being carried out in close proximity to St George's Hospital and without the ICOS method the noise level associated with other techniques in operation over sustained periods would most certainly have necessitated the evacuation of a number of patients.

To help to promote the process and provide publicity, the company has enlisted the aid of a film made on the site at Hyde Park, showing in detail and colour the various stages of the operation. It also goes on to show further examples of the applicaton in Europe and America.

## Twist Drill with a Difference

SIMMS MOTOR AND ELECTRONICS Corporation Limited have just obtained a 50 per cent interest in COLD POINT Limited, a Bahamian Company engaged on the manufacture of a new range of engineering small tools originally patented in the USA. The new products are to be manufactured by HORSTMAN Limited, of Bath, Somerset, a Simms subsidiary, and COLDPOINT DRILLS Limited, a wholly owned British subsidiary of the West Indies concern, will be responsible for research and marketing.

Production will be limited at first to the Coldpoint Drill which has met with some considerable success in the United States. The main advantage it possesses over conventional drills is a bore running longitudinally through the centre of the shank and emerging in the form of two minute outlets located in the extreme tip. Coolant is passed through these two outlets at high pressure. The introduction of a cooling medium at the point serves not only to promote rapid heat dissipation, with a resultant increase in tool life and permissible cutting speed, but the pressure effect washes away the swarf with the result that the tendency towards jamming is reduced and higher feed rates may be employed. The makers claim that there is no material known that cannot be penetrated by this method.

Once the production of the drill has been firmly established in this country, it is intended to introduce a range of tools based on the same principle.

## Office to Further Use of Plywood

A new office has been opened in Liverpool by the PLYWOOD MANUFACTURERS ASSOCIATION of British Columbia, the function of which is to promote the use of Canadian Douglas fir plywood. The address of the new office is: 20 North John Street, Liverpool 2, Lancashire, and it will be under the control of Jack A. McLean, B.Sc. The territory covered by its advisory service will form a line roughly north of Birmingham, along the southern borders of the counties of Montgomeryshire, Shropshire, Stafford, Leicester, Rutland and Lincoln. The Association, which has its main UK office at 1 Grosvenor Square, London W1, is a trade development organization providing technical advisory service for users of weather and boilproof Douglas fir plywood made by member companies in British Columbia.

## More Overseas Contracts for Cementation

Three contracts with a total value of approximately £900,000 have been awarded to the CEMENTATION Company Limited during the past month.

In India, they are to strengthen the Shirawta Dam, which, having been built some considerable time ago, is now regarded as being below the standard acceptable at the present time where modern techniques and methods of construction have facilitated a rise in the strength criterion. The method to be employed at Shirawta is known as the COYNE method and was used in Britain on the Falmouth Dam when it was found necessary to raise its level in order to accommodate a greater volume of water.

This method is ingenious and is based on the insertion of cables to tie in the additional concrete. The dam is part of the Tata Hydro-Electric Power Supply System and this latest contract brings the total value of the work carried out on the scheme by Cementation during the past two years to £750,000.

In Victoria, Australia, the company is to carry out drilling and grouting work on the West Barwon Dam where Cementation will be the sub-contractor, the authority concerned being the GEELONG WATERWORKS AND SEWERAGE TRUST.

A shaft sinking contract has been secured from Goderich, Canada, which will be the second of its type for the same client (DOMINION TAR AND CHEMICAL Company Limited), will be 1,800 ft deep and will form part of the ventilation circuit for a salt mine.

## The Watches of Switzerland

The saying that the chief export of Switzerland is skill is exemplified in her watch industry, where the export market accounts for 95 per cent of the total production.

The export distribution is as follows:

| | |
|---|---|
| Germany .. .. | 44 per cent |
| France .. .. | 19 per cent |
| England .. .. | 7 per cent |
| Japan .. .. | 4 per cent |
| USA .. .. .. | 2 per cent |

The annual production is now in the region of 40 million watches and movements, a figure amounting to just under half the total world production.

In 1960, total earnings for the Swiss economy by the industry were 12,592,000 Sw. frs, compared with 11,246,000 Sw. frs in 1959. Export of watches accounted for one-fifth of total Swiss exports.

## De Havilland Equipment for Indian Pipeline

DE HAVILLAND Pottermeter flowmeters are to be used on a new 720 mile pipeline to be built in North-East India to carry crude oil from the Assam oilfields to the refineries in Gauhuti and Barauni (Bihar).

The equipment is to be built in Britain under licence from the POTTER AERONAUTICAL Corporation of New Jersey, USA, and employs the principle of a turbine rotor revolving in the flow of oil to induce alternating currents in an adjacent coil.

## Underground Power Station Contracts

Three firms who have been successful in gaining contracts to make a contribution towards the construction of the North of Scotland Hydro-Electric Board's underground power station at Cruachan in Argyllshire are ASSOCIATED ELECTRICAL INDUSTRIES Limited, the ENGLISH ELECTRIC Company Limited and EDMUND NUTTALL, Sons and Company (London) Limited.

The power station is to be part of the Loch Awe scheme and Edmund Nuttall are to build the machinery hall and its adjacent control and switchgear rooms. The main hall will be 350 ft long, and 65 ft wide with a roof span 120 ft above the lowest floor level. As far as practical the granite rock will be left exposed where it forms the walls of the hall. In addition to this, two chambers each 45 ft square by 53 ft high will be excavated to accommodate high voltage transformers. A combined ventilating and cable shaft 13 ft in diameter and some 1,050 ft long will link the transformer chamber with the surface substation near the dam. Extensive tunnel work is required on the project and one, about 3,200 ft long and 23 ft in diameter, incorporating a surge chamber, will convey water from Loch Awe to the power station. Two more, 15 ft in diameter and 1,700 ft long, will link the power station with a storage reservoir. In all, the work entails the excavation of approximately 200,000 cu. yd of rock.

The main machinery to be installed in the hall consists of four reversible-type pump turbines, two of which will be supplied by AEI and two by English Electric. Those supplied by the latter concern will have a maximum output of 142,000 hp as pumps and 111 MVA generating capacity and are to be manufactured at the Scotstoun works of HARLAND AND WOLFF Limited. The AEI plant will be of a similar size, the generators being made at their Rugby and Glasgow factories, with the pump-turbines sub-contracted to Boving and Company Limited of London.

The reversible turbine is a fairly new innovation and English Electric's hydro-electric division at Netherton and Rugby has been responsible for much development in conjunction with Sulzer Brothers. The purpose of a pumped storage plant is to equate the daytime peak with the slack period during the night when, despite low consumption, conventional power stations are still running. The function of the reversible turbines at Loch Awe is to utilize the unwanted power during the hours of darkness to elevate the waters of the loch to a storage reservoir 1,200 ft above. During daylight, this head of water will drive the turbines and re-generate the power expended the previous night at a time when it can augment normal supplies to meet peak demand.

## Chemical Plant for Poland

A further step in the steady increase of trade between Britain and Iron Curtain countries was taken recently when CONSTRUCTORS JOHN BROWN Limited signed a two million pound contract with POLIMAX, the Polish government trade organization. Three tonnage oxygen and nitrogen plants will be supplied and installed for use in the production of ammonia at Tarnow in the south of Poland. The firm and its associates already hold substantial contracts for work in the USSR.

The erection of the plants is expected to take about five years and each one will be completed successively. An eventual daily production of 1,000 tons of oxygen and 1,100 tons of nitrogen is envisaged, this being sufficient to produce 1,000 tons of ammonia per day or several times that quantity of artificial fertilizers.

## Kompass Register Appointments

Two new editorial appointments have been made by Kompass Register Limited, RAC House, Lansdowne Road, Croydon, Surrey.

Mr. Herbert R. McDermott becomes Editor of the Information Division, in charge of the editorial staff. In liaison with the 60 Kompass information officers covering the UK, he will edit the company information sections of Kompass and the cross-referencing between the 25,000 companies in the first edition and their products and services.

Mr. Martin G. Frost will be Industrial Editor in charge of the products classification section of the Register. Activities in this category are undertaken in consultation with Trade and Research Associations, major firms in industry and specialists in every field.

# Martin-Baker Mark IV Ejection Seat

**A piece of equipment now standard on military aircraft of 36 countries—a story of human bravery, personal triumph and step-by-step development from first principles.**

THERE is a particular fascination about the science of engineering when it is applied directly to saving human life. During the 17-year history of the Martin-Baker ejection seat it has passed through the normal processes of research, design and development to the stage of becoming not just a highly respected but a well loved piece of equipment.

It is significant that the law of probability, which alone governs whether the ejection seat will ever actually be used as a means of escape, plays no part whatsoever in the design. At the time of writing, 457 successful ejections in which the life of the pilot has been saved are known to have been made, and statistics show that the chances of a seat being used for ejection are about one to forty. But no design sacrifice can be tolerated on this account.

If the static function of the aircraft seat is neglected, then the cost of saving human life can be taken as forty times the cost of one seat—still only a tiny fraction of the cost of an aircraft.

The Martin-Baker seat can therefore look forward to a life of waiting. Its state of readiness comforts the pilot by mitigating his natural fear of what might happen if something went wrong. Such vital readiness demands the strictest maintenance routine, which means, in turn, that one third of Martin-Baker's total ejector seat turnover lies in supplying spare parts.

The seat today owes its inception and successful development to three main factors:—

(1) The increasing urgency of the need for forcible ejection with faster and faster aircraft.

(2) The bravery of a few individuals, in particular Mr. Bernard Lynch, who unhesitatingly risked their lives to act as human guinea pigs.

(3) The genius and inspiration of Mr. James Martin, C.B.E., M.I.Mech.E., F.R.Ae.S., the ejection seat's creator.

## FORCIBLE EJECTION

Many pilots died in their planes during the Battle of Britain due to inability to escape from the cockpit, either from physical injury or some other cause. Remember that even if a pilot succeeds in unfastening his safety belt, the gravitational effect and wind forces tend to hold him in his seat, and the combined effect becomes more pronounced the higher the aircraft speed.

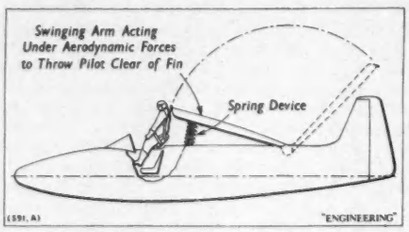



*Fig. 1 Early design using a swinging arm to obtain ejection.*

Early in 1944 James Martin seriously started thinking about forcible ejection and made a study of the fundamentals. In so doing he anticipated by a few months a formal request by the Ministry of Supply to his company and one other to develop a means of pilot ejection, but with no particular method specified. It was believed correctly that two other countries, Germany and Sweden, had successfully produced a means of pilot ejection.

The chief aim of the ejection seat is to lift the pilot out of the cockpit to a height sufficient to miss the aircraft's tail fin by a safe margin. From the start James Martin realized that the pilot and the seat would have to leave the aircraft still strapped together. Fig. 1 shows an early scheme intended for retrospective application to existing aircraft, using a swinging arm to clear the tail fin.

A few demonstrations with a borrowed Defiant showed that the idea of attaching to the seat an ejection gun using explosive was a far more attractive proposition. It would be less vulnerable and create less interference with the aircraft structure. During the war Martin had been responsible for other well known developments depending on explosive charges, such as the balloon cable cutter. The chief problem with using explosive for an ejection seat was that of determining the maximum acceleration the human body could stand without severe discomfort, and controlling the applied force accordingly. Before seat design could proceed more knowledge had to be obtained.

James Martin had a test rig set up at Denham works consisting of a steeply inclined plane up which a trial seat, suitably loaded, could be shot and retained by a ratchet device at the highest point in its travel. The rig was 16 ft high and enabled the accelerations involved in firing the charge to be studied.

## THRILLS AND ANXIETIES

After successful dummy runs, Mr. Lynch, one of Martin-Baker's experimental fitters, volunteered to have a ride in the seat and the first "live" experiment took place in January, 1945, when he reached a height of 4 ft 8 in. Further live tests at increased heights were made until he complained of discomfort at a height of 9 ft 11 in, which represented a peak acceleration of about $3\frac{1}{2}g$.

Then it was the turn of others to take a ride, and the thrills and anxieties of these early days can well be imagined. The 14th live shot proved to be a turning point in early development when Mr. Andrews of *The Aeroplane* sustained a crushed spinal vertebra. James Martin then decided that he must learn more about the behaviour of the human spine as a load carrying structure. He arranged to witness several spinal operations and also obtained a human spine for testing purposes at Denham. He found if the vertebrae were kept square with one another the peak acceleration during ejection could be allowed to reach $20g$, provided that the rate of onset was not greater than $300g$ per second. Now he had some definite data to work on.

The next step was the construction of a 65 ft rig (still used at Denham for routine testing), and trials with a seat having a two cartridge gun providing successive impulses. Mr. Lynch was shot to a height of 26 ft and described the ride as now very soft.

One of the prime factors of urgency behind

*Fig. 2 Basic "ironmongery."*

the early trials was the commencement of delivery of the first jet aircraft to the RAF, the Gloster Meteor. The Ministry of Aircraft Production loaned Martin-Baker a Meteor in order to carry out tests in the air to operational speeds. The first two, using dummies, were failures because the stabilizing drogue parachute became caught in the wake of the seat and entangled with it, though it had operated perfectly at lower speeds. James Martin's answer was to employ another gun to extract and deploy the drogue, a scheme which has ever since proved eminently successful.

In July 1946 Lynch made history by performing the first live ejection in this country, at a speed of 320 mph. It proved to be the first of a series of successful life ejections at increasing speeds and altitudes, and it is largely due to this dress rehearsal technique that the Martin-Baker seat has reached a position of such eminence in the aeronautical field today.

An important facet of the business of supplying ejection seats is the variation imposed by the different types of aircraft to which they are applied. The basic design makes few demands on the aircraft structure and remains the same. But an approximate average of 30 per cent of its components have to be tailored for the job. Therefore in order to continue supplying seats a drawing office with about 40 draughtsmen is kept busy working out new variations on the seat to suit new aircraft coming into service. This work involves a detailed knowledge of the design of the aircraft so that its structure can be properly integrated with that of the seat. The inability to standardize on seat design also introduces problems of production continuity.

The current Mark IV seat is the result of two processes: (1) introducing more and more sophistication to still further improve the general reliability and justify the pilot's confidence and (2) keeping up to date with current aircraft performance. It is designed not only to provide

Fig. 3 Although only one in forty will ever be used, no design sacrifice can be tolerated.

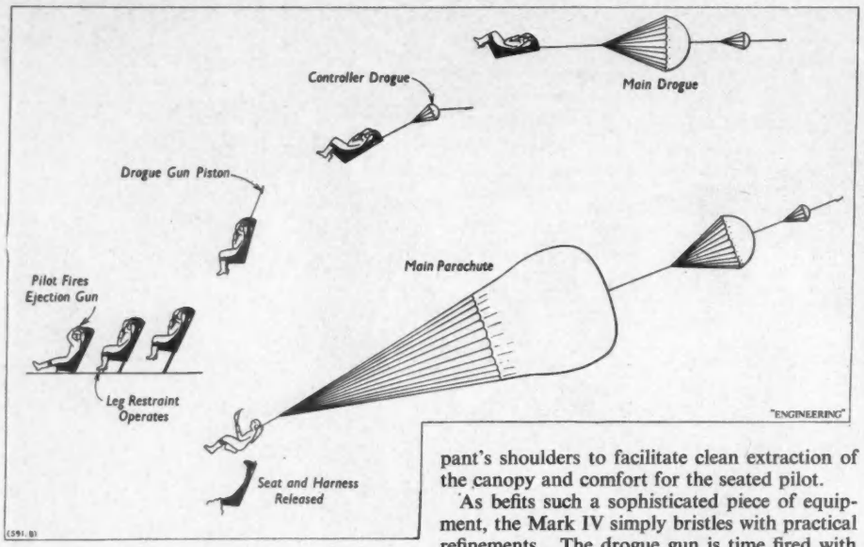



*Fig. 4 Ejection sequence.*

safe ejection from the aircraft; but also to deploy the parachute automatically and lift the pilot out of the seat. The pilot has nothing to do beyond firing the seat. Pulling the mask down over his face fires the ejection gun and sets off a train of events that finally leaves him dangling on the end of a perfectly normal parachute.

## FACE MASK FIRING

Apart from protecting the pilot's face as he leaves the cockpit, the advantage of the face mask method of firing is that it holds his head back against the seat and keeps his spine in the best position to withstand the force of ejection without discomfort. An alternative firing handle is also provided.

The telescopic ejection gun gives a velocity of 80 ft per sec and serves the dual purpose of providing the power for ejection and forming a basis of a guide system to preserve directional correctness through the cockpit opening. It comprises three telescopic tubes, the outer one forming the cylinder barrel. The barrel is attached to the aircraft structure at two points, one at cockpit floor level and the other adjustable at the top to pick up a convenient strong point.

Power is provided by one primary and two auxiliary charges. Firing the primary causes the inner and intermediate tubes to rise due to the internal pressure of the generated gases. The two auxiliary cartridges are fired by the flame when corresponding ports are uncovered after travels of 15 in and 26 in respectively. The intermediate tube is stopped from leaving the outer tube when it reaches the end of its travel and the inner tube finally leaves it still attached to the seat. The total stroke of the gun is 65 in.

The seat structure is made as light and simple as possible consistent with adequate strength to withstand ejection forces. The basis is two side beams about 6 in apart bridged by three cross-beams. It is rail mounted on the ejection gun by three pairs of slippers fitted to the inside of the beams engaging in guide rails on the outer cylinder barrel. The full thrust of the ejection gun is taken by the top cross member of the seat framework. A patent latch mechanism keeps the seat locked in position and can only be released deliberately, i.e., for maintenance, or by the forces induced by detonation of the primary charge. The main parachute is stowed in a horseshoe wedge-shaped pack behind the occupant's shoulders to facilitate clean extraction of the canopy and comfort for the seated pilot.

As befits such a sophisticated piece of equipment, the Mark IV simply bristles with practical refinements. The drogue gun is time fired with a $\frac{1}{2}$ sec delay and the main parachute release and harness release mechanisms automatically operate after a further $1\frac{1}{4}$ sec. A barostatic control attached to the seat is arranged to delay the opening of the main parachute if ejection takes place at an altitude higher than about 10,000 ft. The purpose is to allow the pilot to descend rapidly through the cold rarified atmosphere, strapped to his seat and steadied by the duplex drogue parachutes, to a more tolerable altitude before the automatics start to operate, see Fig. 4. Emergency oxygen is supplied automatically to the pilot on ejection.

A problem with ejection seats is that of providing leg restraint at the instant required to prevent the pilot from injuring his feet against the front of the cockpit. The Martin-Baker patent gear depends upon two reinforced nylon cords passing through eyes in a pair of calf straps, which are normally slack to allow the pilot foot movement. The cords are connected to the cockpit floor by a special roller bracket designed to pull away at a predetermined load and keep the pilot's legs against the forward edge of the seat pan until such time as the harness is released. Other ancillary but vital items of equipment used with the seat are a buoyant life saving waistcoat and a survival pack stowed beneath the seat pan.

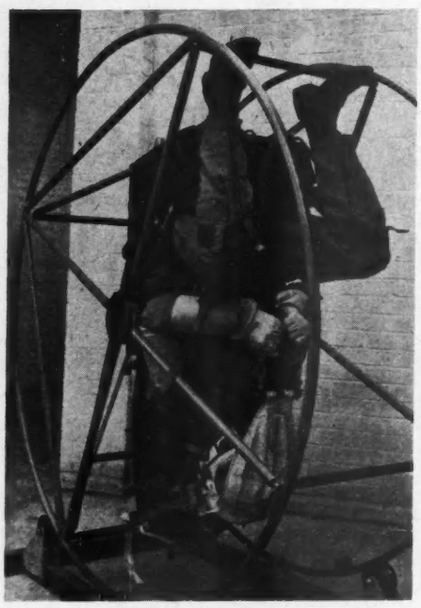


*Fig. 5 Ejection seat in a rotating rig. The pilot's arms are weighted with lead to demonstrate that the seat can be operated under negative g conditions.*

The harness comprises a white personal harness and a separate blue harness. The personal harness is donned before the pilot enters the aircraft and the two harnesses are interconnected when the pilot is in his seat. Their most important function is to keep the pilot securely in his seat after ejection until the seat has been retarded and stabilized by the two drogues.

The main point to remember about the Martin-Baker Mark IV is not simply the degree of automation built into it, made necessary by the stress of circumstances under which ejection generally takes place; but that it goes through its sequence with the minimum loss of time. The importance of the time factor is due to the fact that the great majority of ejections take place within a comparatively narrow band of speed at a low altitude.

Emergencies tend to arise near the beginning or end of a flight; but even when they occur with plenty of height to spare, it is only human nature to endeavour to save the machine if it is simply an engine failure or an empty fuel tank. Where accidents have occurred with Martin-Baker seats the cause has almost invariably been that the pilot has left ejection too late, and has not allowed for the nose-down position of the aircraft.

## SAFE EJECTION HEIGHT

The altitude of the aircraft during ejection is another vital factor. When it is diving the pilot will be thrown forward by a component of the ejection velocity plus the speed of the aircraft, and if close to the ground the parachute may not have time to open. To counteract this effect the path of the ejected seat relative to the aircraft is upwards and backwards. It is not simply the height of the trajectory that is so vital to safety, but also its shape.

This consideration has led Martin-Baker over the past two years to explore and develop the idea of solid fuel rocket propellent in place of the explosive charge. A trajectory height of at least 300 ft is considered desirable, particularly in association with VTOL aircraft having a high sink rate. One of the many problems which adds time to such development is that a rocket propelled seat, to become established, must also be capable of retrospective application to existing types of aircraft.

The rocket seat has now reached the live testing stage, and with James Martin in charge it can only be a matter of time before another outstanding piece of aircraft equipment emerges from the Martin-Baker stable. The firm that set up its factory at Denham in 1929 with two staff on the payroll and the hope of eventually becoming leading aircraft manufacturers, has succeeded in spreading its wings with conspicuous success in other directions. The Mark IV has attained considerable popularity in the USA, slightly modified to comply with American standards.

Though close service liaison is maintained with the many air forces using the seat, often Martin-Baker receive first hand information about a successful ejection by letter from a pilot, grateful that his life has been saved. In such instances the pilot is usually invited to Denham works to witness seat production for himself and to meet some of the 1,250 employees. This friendly arrangement preserves an atmosphere of consciousness among the staff of the part they are playing in saving human life.

## Large Rocket Engine Demonstrated

The US National Aeronautics and Space Administration's F-1 engine, the most powerful unit known, was recently shown to the public for the first time.

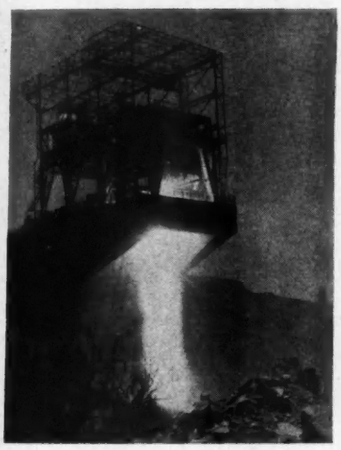
The F-1, which has a thrust of 1·5 million lb, is being developed for NASA by Rocketdyene, a division of North American Aviation, Incorporated, under direction of the agency's Marshall Space Flight Centre in Alabama.

The test programmed for the first public showing was regarded as another step in the build-up to a test of the engine at full thrust of 1·5 million lb and a duration of two and one-half minutes.

The decision to develop the F-1 was one of the first made by NASA after its establishment in October, 1958. The decision was made on the basis of an urgent, foreseeable need for a large thrust engine to power large space vehicles for such missions as manned circumlunar flights and landing a man on the moon and returning him to Earth.

Such a large vehicle—designated Nova—existed only as a design concept for several years.

On May 25, 1961, in his message to Congress on urgent national needs, President Kennedy urged an accelerated programme to land man on the moon and return before the end of the decade. He requested that Congress appropriate $48·5 million to initiate design and development of the Nova vehicle.



*Developing more than 1 million lb thrust in its first test series, the F-1 rocket engine may eventually be used for a manned expedition to the moon.*

Congress approved the fiscal 1962 NASA appropriation bill on August 7 this year and design work will begin on Nova as soon as the bill is signed into law by the President.

It is possible, however, that first use of the F-1 engine could be in an advanced Saturn booster designed approximately to double the power of the Saturn C-1 booster. One possible configuration would be powered by a cluster of two F-1's for a lift-off thrust of 3 million lb.

The Saturn C-1, with 1·5 million lb lift-off thrust developed by eight Rocketdyne H-1 engines, will carry the three-man Apollo spacecraft in Earth orbital scientific missions of up to two weeks. The second stage is a 90,000 lb thrust S-IV, powered by six Pratt and Whitney RL-10-A3 liquid hydrogen—liquid oxygen engines.

The first test launch of the C-1 booster with two inert upper stages is scheduled for later this year. The advanced Saturn referred to above could be used to place the Apollo spacecraft into orbit about the moon and return it to Earth. One configuration under study for the first stage would consist of two F-1 engines; the second (S-II) stage of four J-2 200,000 lb thrust liquid hydrogen—liquid oxygen engines also under development by Rocketdyne; and the third stage would be the S-IV. This possible configuration would be capable of lifting an approximate 30,000 lb payload on a lunar mission.

The F-1 has been under development by NASA for two and a half years. But earliest feasibility studies on a million-pound thrust single chamber engine date back to 1955—two years before the first Sputnik—when Rocketdyne proposed such an engine to the Air Force.

In January, 1959, a $102 million NASA contract for development of a full-scale 1·5 million lb thrust engine was initiated. This was followed by a long series of exacting tests. Each component was tested and re-tested to assure maximum reliability and top performance. Then, in a series of carefully prepared tests, the components were gradually assembled for full-system firings.

The first complete engine test was made on 13 June, 1961, at the $15 million high thrust test area at Edwards, Calif. A thrust of approximately one million lb was generated at that time. This achievement was of high significance to the American space effort.

## Research into Mechanized Plastering

The National Federation of Building Trades Employers have announced the inauguration of a planned programme of research into the mechanization of plastering operations.

The new developments in plastering which were discussed at a conference in London in June, organized by the National Federation of Plastering Contractors, have aroused considerable interest in the industry.

One of the subjects discussed at that conference, the increased mechanization of plastering operations, is now to be the subject of research by the Building Research Station in full collaboration with the National Federation of Plastering Contractors.

As a result it is hoped to provide the industry with an objective account of what part machines can play in producing good plasterwork. Some of the subjects which will be dealt with are: what mixes are most suitable for machine plastering; the quality and durability of machine-applied as compared with hand-applied plaster; the kind of operation for which mechanized plastering is most suitable; the capabilities of existing machines and how they can be improved.

It is expected that the results of the inquiry will give a considerable impetus to the development of mechanized plastering and will thus help in the solution of one of the main difficulties of the plastering craft, namely, the present acute shortage of craftsmen.

The National Federation of Plastering Contractors hope to begin this cooperational research programme with the Building Research Station early in September.

## Flash Welding of Light Alloys

A process that makes feasible for the first time production-run flash-welding of aluminium, magnesium and magnesium-thorium alloys has been developed by engineers at Lockheed's California Division.

First production use of the technique, which results in 40 per cent stronger welds for as much as 75 per cent lower processing costs, was in manufacture of aluminium alloy structural rings for missiles.

"With the new method, we can join light-weight aluminium and other alloys that do not respond to ordinary fusion welding," said Mr. E. A. Green, the division's value engineering manager. Mr. Green said a modified 400 kVA flashwelder performs the work.

"Joints are as strong as the parent material and, depending upon part complexity and quantities, manufacturing costs are cut from 25 to 75 per cent. Welds are made automatically after the machine is pre-set by an operator," he added.

The technique was developed by engineers in the Lockheed producibility methods group, during a study funded by the US Air Force Air Material Command.

Flash welding, long used with steel, is accomplished by heating metal electrically to forging temperatures then bringing the ends together mechanically—"upsetting" it to make the junction. In fusion welding, ends are placed together, heat is applied and they are fused into one part.

## Ruby Maser As Light Amplifier

A pulsed ruby optical maser has now been operated as a light amplifier. Drs. P. P. Kisliuk and W. S. Boyle of Bell Telephone Laboratories, USA, reported this as the result of an experiment in which two ruby masers were set up in tandem. A pulse of light from one maser, operating as an oscillator, was beamed into the other. Amplification of the light by a factor of two was observed.

Although it has been known previously that maser oscillators amplify light enough to make up for losses at the end mirrors, this is the first time results have been obtained in an experiment designed to observe and measure such large amplification directly.

The difficulty in observing amplification directly is that of distinguishing coherent maser light from the natural fluorescent light of the maser. In the experiment by the Bell research engineers, this problem was solved by using a ruby maser

*A light beam from a ruby maser amplifier (right) passes through an amplifier (centre) to a photomultiplier tube (left).*

oscillator to generate a coherent light which was so bright that the amount of fluorescence from the amplifier ruby was comparatively small. The amplifying ruby was similar to a light-source ruby except that the ends of the ruby rod were not silvered.

The two rubies were fired simultaneously. The output from the amplifying ruby was then measured by a photomultiplier tube. Both the signal going into the amplifier and the signal coming out were displayed on a dual-beam oscilloscope.

Gain was measured by comparing the output-to-input ratio, when using the amplifier, with that obtained when the amplifier was removed from the beam. The amount of gain that can be obtained depends on the temperature of the amplifying maser and the pumping power. A net gain of a factor of two was observed at −40° C. Dr. Kisliuk said that with a more precise experimental set-up and greater control of temperature, it undoubtedly will be possible to obtain a larger amplification.

He also said that the potential applications of optical masers are just being explored and that maser amplifiers may eventually be as important to communications as maser oscillators.

# Two Facets of Economic Central Heating

**Two current research projects of the Heating and Ventilating Research Association—intermittent heating and operational research—are aimed at lowering the running and installation costs of industrial central heating systems.**

THERE are several factors which can affect the running economy of a central heating system in a large building; choice of fuel, boiler capacities and maintenance costs being among the primary ones. The importance of such factors is fairly well understood and a reasonable amount of design data exists to assist the engineer in his choice.

However, there is another important parameter governing the economics of heating, about which far less quantitative information is available. This is the factor which relates the active boiler period to the heat-utilization period. In other words, if, as is usual, a building is only being used for part of the day and part of the week, then there is a need to establish an optimum period during which the boiler should be actively generating heat. In very few cases can it be argued that a 24 hours a day, seven days a week, period is the optimum one for boiler operation.

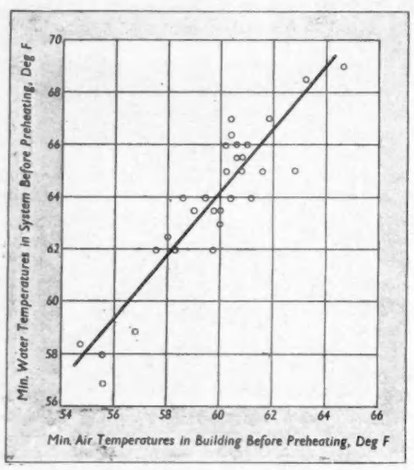
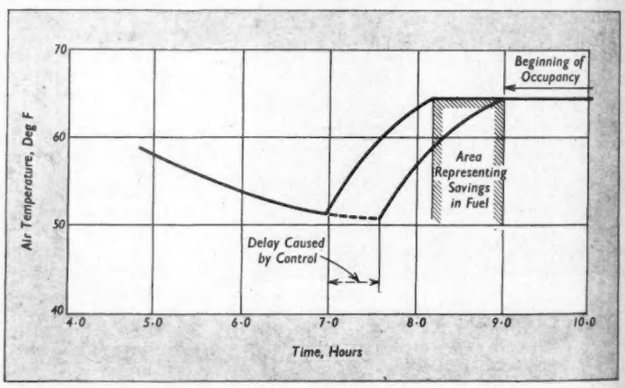



*Fig. 1 (Left) Relationship between water and building temperatures prior to commencement of heating.*

*Fig. 2 (Right) Automatic control can save fuel by delaying preheating.*




## Intermittent Heating

At first sight it seems fairly obvious that a building which is only in use for a fraction of the day need not have its heating system on for the whole day. However, although it is easy to see an argument for intermittent heating, it is not nearly so simple to arrive at an optimum cycling schedule. Indeed, so complex are the factors governing optimization that it is not even possible to quantitatively substantiate the arguments in favour of intermittent heating, except by individual analysis of installations.

Because so little data are available to guide engineers on the economic optimization of heating systems in a general manner, the Heating and Ventilating Research Association have given the matter high priority in their research programme. Their aims in this work are first of all to establish a case (or otherwise) for intermittent heating in various categories of buildings and then, through theoretical studies and controlled experiments on existing installations, to arrive at design data which will give guidance on optimum boiler capacities and heat-cycling times.

Experimental work has already progressed to a fairly advanced stage and, although conclusive results have not yet been achieved, considerable evidence in favour of intermittent heating has been brought to light. During the season 1960-61, controlled experiments were made on four buildings to determine the relative economic pros and cons of intermittent and continuous heating. In these experiments, the buildings were heated first by one method and then by the other under conditions which ensured that the inside and outside temperatures were approximately the same for each case. The boilers were oil-fired in each installation and the buildings were all of medium to light structure.

## Clear Savings

Although the results of these investigations have not yet been fully analysed and published, there is a clear indication that in buildings which shut down completely overnight and are occupied for about 35 to 40 hours a week, a fuel saving of the order of 20 to 30 per cent can be effected by intermittent heating.

These investigations have been worthwhile in that they have established a clear case for intermittent heating in the types of building investigated. However, this has not by any means been the sole object of the exercise. The longer term aim is to determine the heating and cooling properties of various types of building, bearing in mind such variables as ventilation, period of occupancy and type of heating system, and to establish design formulae for optimum heating cycles and excess capacity of boilers.

It is anticipated that this will involve the classification of buildings into at least three types; light, medium and heavy construction. Recommendations could then be made for excess boiler capacity and optimum preheat times and rates for any type of building. Whether or not the wide variations that exist in methods of ventilation will detract from the value of such data remains to be seen. There can be little doubt that a building in which there is no designed control over ventilation can either become uncomfortably cool or unduly costly to heat. It may well be that better control over ventilation will have to accompany any optimization of the heating cycle, in order not to defeat the object.

Ventilation is not the only factor which seems to require improved control in order to effect economies in heating. Many radiator valves themselves appear to have insufficient control over the flow of hot water passing through them. This has lead to the tendency for valves to be used as switches—either full on or full off. Consequently, in mild weather, radiators are often left on at full capacity and the temperature of the room then regulated by opening windows. In terms of heating economy, this is an absurd situation.

Realizing the functional inadequacy of many types of radiator valve in common use, the Heating and Ventilating Research Association have made a study of the problems involved and have shown that a redesigned valve could provide better control of radiation temperature.

## Automatic Control

Yet another form of heating control which the Association have concerned themselves with is the control of preheating time, in connection with intermittent boiler activity. It is normal practice to set the preheating time in accordance with the temperature of an average point in the building. That is to say that one or several positions in the building are taken to represent the average temperature conditions in the whole building. From temperatures observed in these rooms, preheating schedules are selected and the time switches set to give the desired heating schedule. The selection of preheating times are usually fixed at a constant value for most of the week, with an earlier switch-on for Monday morning only.

With this method, no automatic adjustment is made to prevent the building being heated earlier than necessary, when temperature conditions in the building are such that the full preheating period is not required.

A method has therefore been developed in which a thermometer in contact with the water in the heating system is made to actuate simple electrical switches. Prior to this development, analysis of temperature records taken over various heating seasons showed a strong correlation between the minimum average building temperature and that of the water in the system prior to the preheating period. This is explained by the fact that when the boiler is switched off, the water distributed through the building's heating system cools down to a temperature approaching that of the surroundings. So that, at any time after the boiler is turned off, the

**Research Report**

on work of the

**Heating and Ventilating Research Association, Old Bracknell Lane, Bracknell, Berkshire**

*Director of Research*

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average temperature can be determined by recirculating the water for a short while and then measuring its temperature. Fig. 1 shows a number of recordings that have been made in order to establish the linear relationship between water and building temperature.

Experiments comparing the new automatic control system with other forms of control have shown that further fuel savings can be made. Fig. 2 shows the way in which savings can be made by delaying the boiler switch-on time to ensure that comfort temperatures in the buildings are reached only at the commencement of the occupied period and not at some time earlier.

## Operational Research

Whilst automatically controlled intermittent heating is one way of economizing on costs, further savings can undoubtedly be made in the installation. In particular, it is thought that research into the operations involved in erecting and fitting a complete heating system may be valuable—not only in terms of money saved but also in improved safety for fitters handling very heavy pieces of plant. Such research is also likely to reveal techniques which will lower the running costs of a system after it has been put into operation.

There are many operations carried out on site which have not yet been brought under the rational control of the design engineer. One example, which has been studied thoroughly by HVRA, is the common operation of joining pipes.

Both screwing and welding are used on site to join lengths of pipe. It is fairly obvious that screwing is the best method for small diameter pipes but, as pipes increase in diameter, welding becomes a better technique. This being the case, there must be a range of diameters in which screwing is the better method; beyond this range, welding methods should be employed. However, the point at which these two ranges meet, that is, the pipe diameter at which welding should take precedence over screwing, has never been defined on a scientific basis.

Whilst it is realized that there may be no unique answer to this question, it was decided to investigate the matter fully in order to establish design data on which this seemingly simple question could be decided with some confidence.

The investigations were confined to sites where low pressure hot water systems were being installed. No pipe diameters over 4 in were considered since larger pipes would almost always be welded. Arc welding techniques had to be ignored since few opportunities for observing its use were available.

For the particular conditions of this study some general recommendations can be made:

1. Powered screwing machines can be more economical than hand-operated equipment and show a decided advantage over pipe mounted diestocks for the lower diameters.

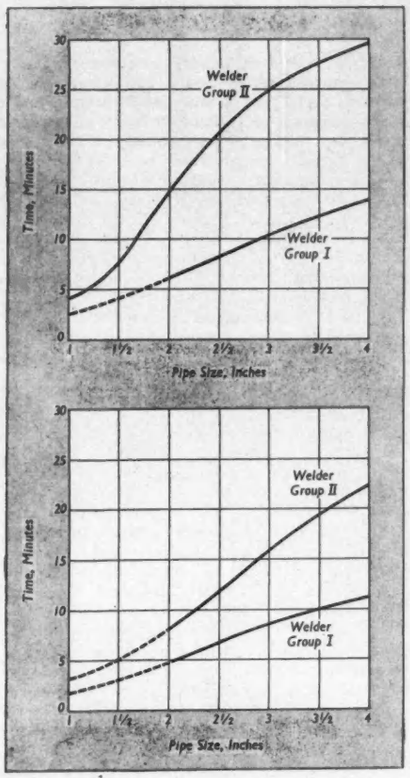



*Fig. 3 Time required to produce a circumferential weld by two distinct groups of welders, (above) positional weld, (below) bench weld.*

2. The powered hacksaw is not an economical site tool unless other work is carried out whilst it is in operation.

3. For producing a butt or socket joint there is little to choose between welding and screwing at small diameters, but as sizes increase hand cutting becomes uneconomical.

4. For producing T-joints, screwing is cheaper for the smaller sizes. The use of welded T fittings is not economical compared with fabricated T's.

5. Screwed reducers are cheaper than welded reducers, whether made with fitting or fabricated, throughout the range considered.

In general, the conclusions indicate that joints in small diameter pipes should be screwed. For the larger pipes, the decision will be influenced by whether or not a screwing machine is available and by the quality of the welder.

On the question of welders, HVRA research engineers found that some welders consistently produced faster times than the majority of others. Although the quality of welds made by the faster operators may have been slightly lower than others, it was generally found to be perfectly satisfactory. It is believed that these observations indicate a need for some revision in training methods for welding operators since most of the speedier welders had in common a background of experience and training in which speed had been accentuated. Fig. 3, taken from a HVRA report, indicates the considerable differences between the two groups of welders. The report stresses the point that laziness or inefficiency are not believed to be the reasons for the slower welding times of the majority of operators.

Another facet of the operational research programme of HVRA is materials handling. Fig. 4 gives an indication of the extent of the problem of handling some of the bulkier materials on site. In this illustration, cast-iron boiler sections are being man-handled into position. The difficulty, danger and time-wasting factors of such a method of handling are fairly obvious but it is not nearly so obvious a matter to find techniques for improvement since no two site operations of this nature are exactly alike.

The first likely solution to the problem appears to be to make use of some form of crane or gantry to make the job quicker and safer. But such a device needs to be light, portable and capable of being erected in confined spaces. No such equipment is currently marketed; therefore, the HVRA have looked into the possibility of designing a simple gantry to meet these special requirements. A model of what appears to be a very suitable device has now been built in the laboratory and it is hoped that this will lead to the development of a full-scale gantry which will be widely used by site fitters.

The handling of radiators themselves is another matter that has been looked into. At the moment, radiator sections are usually carried into place by two or more men. Therefore, if one man could satisfactorily do the job, a considerable labour saving could be affected. By designing a rather ingenious trolley, which one man could easily operate, HVRA research engineers appear to have solved this problem.

## Ventilation Ducts

Ventilation ducts have a very high size-to-weight ratio, they are therefore costly things to transport from factory to site. Seeing in this another opportunity to cut installation costs, the operational research team have devised a technique for making duct sections on site. If this can be made to work satisfactorily, it will undoubtedly be of economic interest. A section of ducting made by this technique is shown in Fig. 5. The tools and operations involved in making and joining the sections are simple, but the problem of making the system air-tight has yet to be overcome. If no solution to this problem can be found, then the technique may still have a valuable application in making outlet ducting.

*Fig. 4 Studies have been made of the problems involved in man-handling bulky plant.*

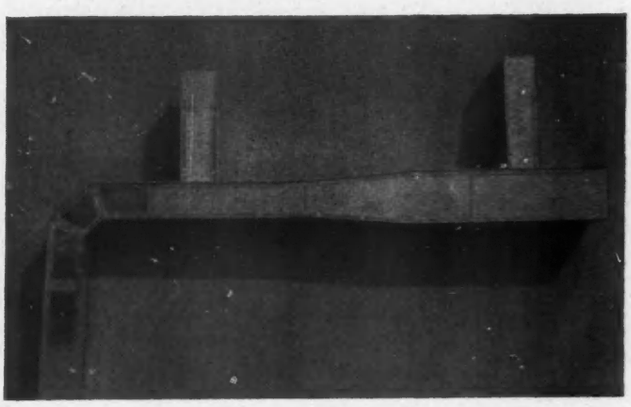


*Fig. 5 Section of ducting made by a technique that has been found suitable for use on site.*

At Home

# Model Charm

THERE is a peculiar fascination about models. It existed in prehistoric times—toys have been found in the earliest tombs that have been true models of the real thing and models have been found that served symbolically to carry the dead to their final home. The minuteness has something to do with it and the same comparison of size is one of the perennial interests of *Gulliver's Travels*.

The 34th Model Engineer exhibition (which was held this year at the Central Hall, Westminster, from 16 to 26 August) was once again a revelation of how much detail could be concentrated in how small a space. It was also a faithful representation of many, many hours of loving labour.

Models that get as far as the exhibition are, of course, the cream of the field. The tens of thousands that never achieve fame may not reach the same standards of perfection but the joy of making them remains, and with it the mental exhilaration of having done some creative thing. Since there are so many jobs nowadays in which the end product is never seen by the worker, this is no small matter. Although the pundits may look askance at making up models from a kit of parts (for them a scratch start is necessary even to making the tools that make the model) yet the sense of achievement is still obtained and is made possible for those whose skill, time and facilities may not be equal to the major task. A very great many inventions have started from models too—and not always made by so-called experts.

The locomotive has at last been displaced from its leading position in the exhibition, at least as far as numbers go. This year the lead was taken by ship models which made up some 75 per cent of the total of 1,000 models on show. The smallest were two early English ships about 2 in long made by Miss Jennifer Barton and the largest the 10 ft "O" class submarine made by Mr. D. G. Ashton which is radio controlled, fires missiles, winks its signal lights and is made largely from resin-reinforced glass fibre. It weighs some 200 lb and has so far been building for six years and is expected to be finished in a few months, when it will undergo its "trials."

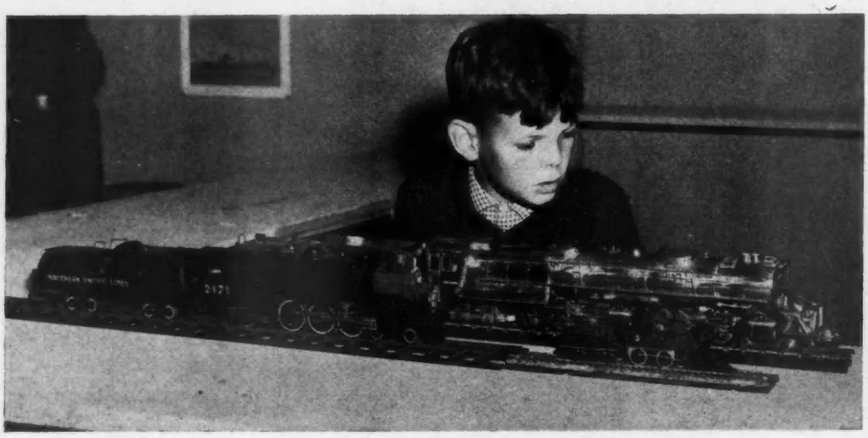
The "Olympus" (she is modelled after the submarine of that name which was sunk in 1942) is an excellent example of what can now be achieved with radio control. Three uniselectors in the hull will be operated from a 10 channel transmitter to control the various features. The twin propellers are driven by two 24 volt motors (obtaining their power from batteries) with a choice of two speeds. Five servo motors raise and lower the hydroplanes; traverse the rudder (it is arranged so that should there be a failure it will swing from side to side and prevent the vessel from continually moving in a circle); flood and blow the tanks for submerging and surfacing; open the doors and fire torpedoes both fore and aft; traverse and fire a gun on the fore deck; signal with Aldis lamps; fire a Polaris missile (an anachronism); and release a winking marker buoy should the submarine fail to surface after a dive. Much remains to be tested in the hard school of practice and it is expected that reaching the vessel while she is under water may present some radio communications problems. It is these unknowns that make up so much of the fascination of working models.

The exhibition was opened by Sir Miles Thomas who commented on how model making (and reading about models) had influenced his own career. He also brought out the relaxation obtained by the joy of hand work and in particular mentioned the delight he gained personally from a model of a motor cycle on show, which was almost incredibly complete in detail. The same sort of satisfaction must be the perquisite of an artist who has produced a masterpiece.

The range of models was indeed wide—and some of them could only just be classed within the title of engineering. A church with a mechanically-operated peal of bells would probably qualify, but what of the display of shoes of all ages made so convincingly in copper, brass and aluminium? Period models always lend themselves to picturesque detail and this reached high levels in models of beam engines and an atmospheric engine. A showcase model of Cugnot's steam carriage (chassis only) could be counted as one end of power transport, while the other was surely a 1·5 cc Wankel engine adapted for use in model aircraft.

As ever, railways and locomotives were popular although as mentioned earlier they gave pride of place as regards numbers to ships. Is this a reflection on the slow demise of the steam locomotive from our system? The outlines of an electric locomotive do not offer the same possibilities for detail as may be found with steam; its exterior is so essentially smoothed. Nor is there the valve gear and rodding to copy. A model of "Puffing Billy" demonstrated the older generation in contrast to the latest giants. Space to operate indoor model railways presents a problem these days, with a resultant general decrease in scale size. Several models could not have been to a scale greater than 2 mm to the foot.

This is essentially an amateur's exhibition. Most of the models were made in home workshops, often nothing more than the kitchen table, as was actually the case for the group of locomotives in the illustration. Could it be that this is the secret of the popularity of the ship? Most ship models are wood, while engines are steel; wood can be worked on the dining room table (with permission!) but steel cannot, and a work room is a luxury in a modern house.



*Three American locomotives—made on the kitchen table—exemplify the craftsmanship displayed at the Model Engineer exhibition.*

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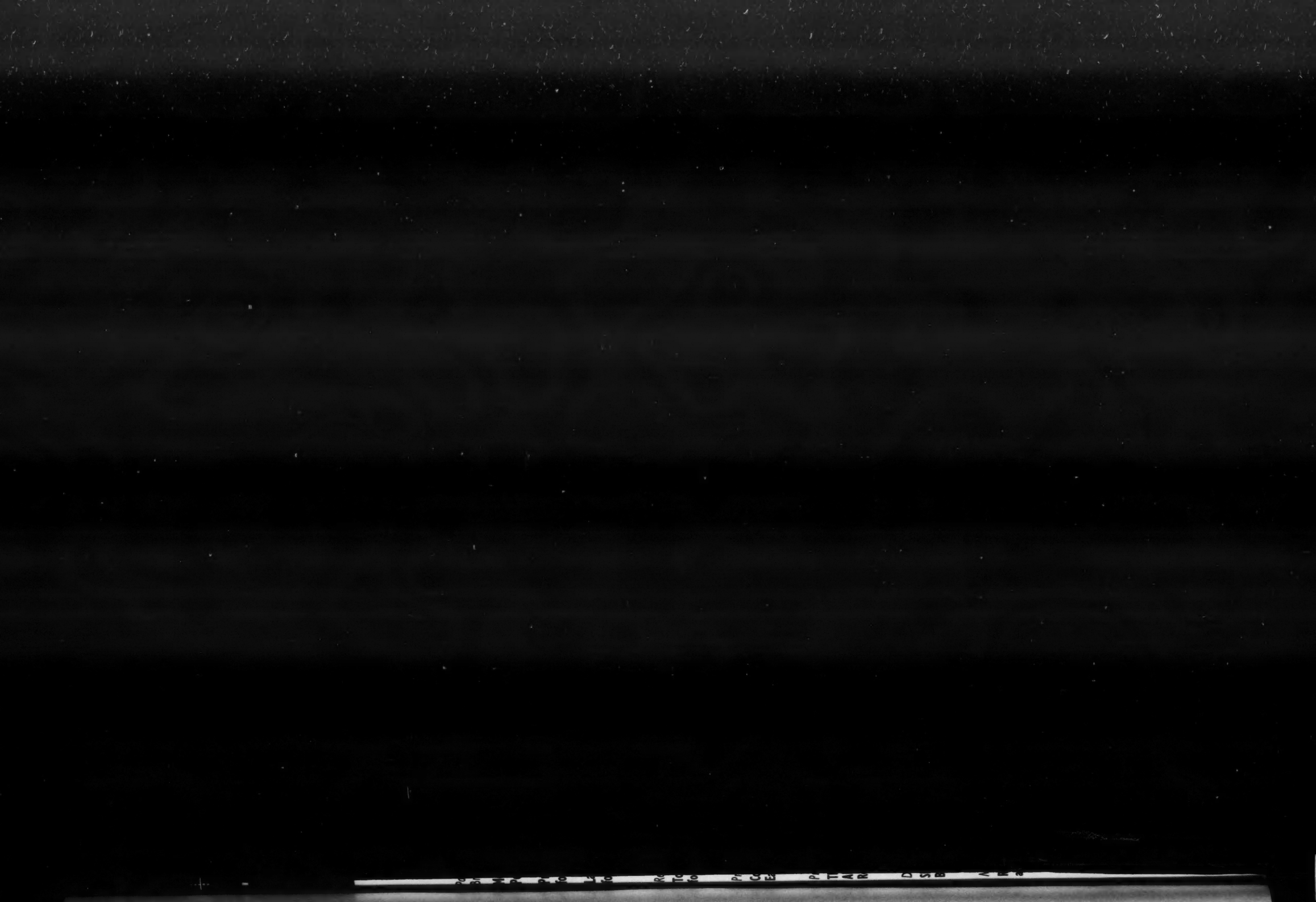
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